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COMPREHENSIVE STUDY OF WATER AND RELATED LAND RESOURCES. PUGET --ETC(U)
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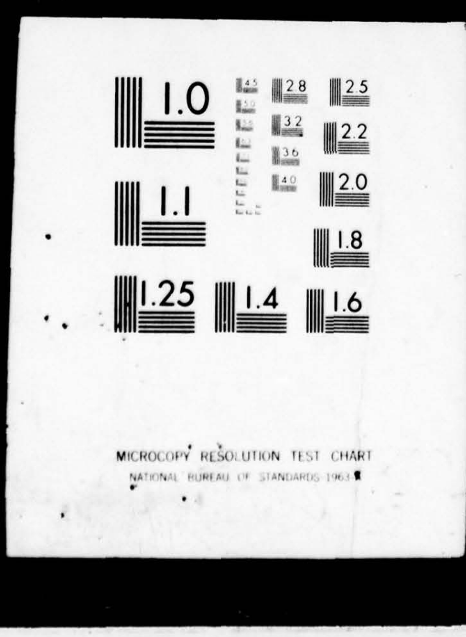

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B.S.

Comprehensive Study of Water and Related Land Resources

# Puget Sound and Adjacent Waters

State of Washington

## Appendix XIV
## Watershed Management



Puget Sound Task Force—Pacific Northwest River Basins Commission

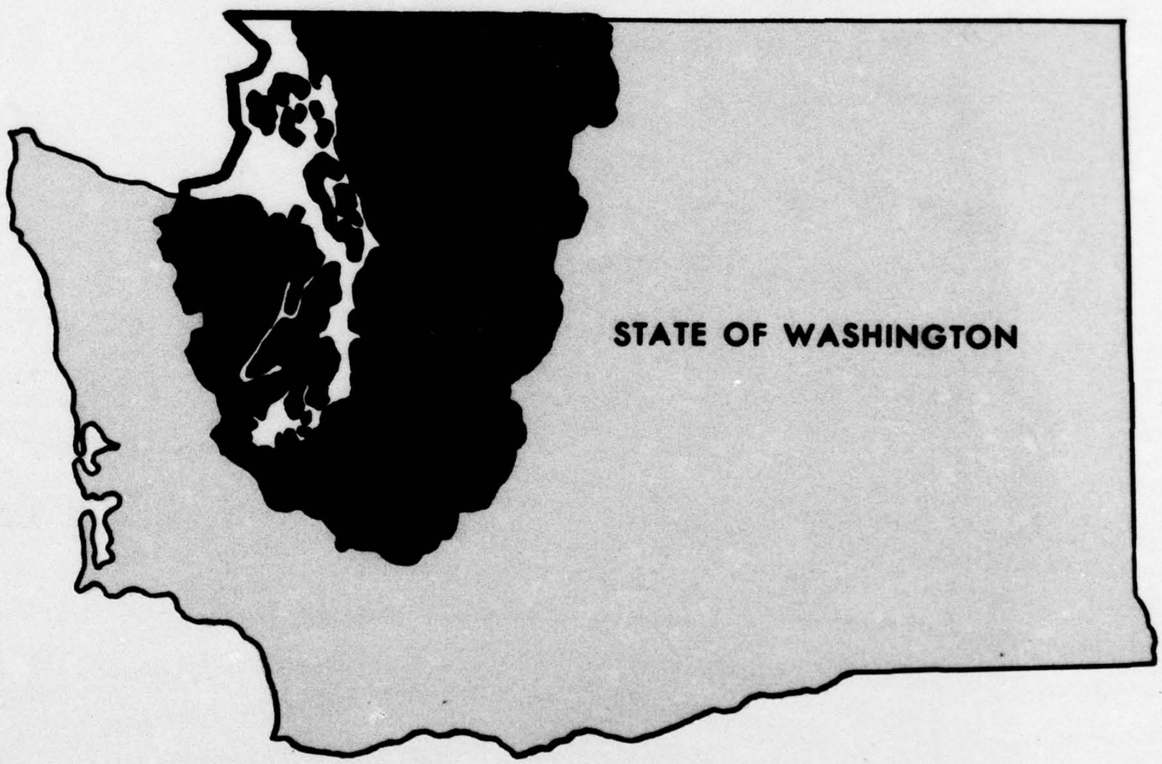


March 1970

# PARTICIPATION

## STATE OF WASHINGTON

Department of Agriculture
Department of Commerce & Economic Development
    Office of Nuclear Development
Department of Fisheries
Department of Game
Department of Health
Department of Highways
Department of Natural Resources
Department of Water Resources
Canal Commission
Oceanographic Commission
Parks and Recreation Commission
Planning and Community Affairs Agency
Soil and Water Conservation Committee
Water Pollution Control Commission




## FEDERAL

U.S. Department of Agriculture
    Economic Research Service
    Forest Service
    Soil Conservation Service
U.S. Department of the Army
    Corps of Engineers
U.S. Department of Commerce
U.S. Department of Health, Education & Welfare
    Public Health Service
U.S. Department of Housing
    and Urban Development
U.S. Department of Labor
    Bureau of Employment Security
Federal Power Commission
U.S. Department of the Interior
    Bonneville Power Administration
    Bureau of Indian Affairs
    Bureau of Land Management
    Bureau of Mines
    Bureau of Outdoor Recreation
    Bureau of Reclamation
    Federal Water Pollution Control Admin.
    Fish and Wildlife Service
    Geological Survey
    National Park Service
U.S. Department of Transportation

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# Comprehensive Study of Water and Related Land Resources.

# Puget Sound and Adjacent Waters.

## APPENDIX XIV.

## WATERSHED MANAGEMENT



10 Alfred T. Neale, Sydney Steinborn, Lewis F. Kehne, L. B. Day Francis L. Nelson

11 Mar 70

12 580p.



ORIGINAL CONTAINS COLOR PLATES: ALL DDC REPRODUCTIONS WILL BE IN BLACK AND WHITE.

**Drainage and Land Stabilization Technical Committee**

**PUGET SOUND TASK FORCE of the PACIFIC NORTHWEST RIVER BASINS COMMISSION**

**1970**

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| Sydney Steinborn | U.S. Department of Army |
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# FOREWORD

Appendix XIV, Watershed Management, contains a detailed report of one component of the Comprehensive Water Resource Study of Puget Sound and Adjacent Waters. It is one of fifteen appendices providing supporting data for the overall water resource study.

The Summary Report is supplemented by fifteen appendices. Appendix I contains a Digest of Public Hearings. Appendices II through IV contain environmental studies. Appendices V through XIV each contain an inventory of present status, present and future needs, and the means to satisfy the needs, based upon a single use or control of water. Appendix XV contains comprehensive plans for the Puget Sound Area and its individual basins and describes the development of these multiple-purpose plans including the trade-offs of single-purpose solutions contained in Appendices V through XIV, to achieve multiple planning objectives.

River basin planning in the Pacific Northwest was started under the guidance of the Columbia Basin Inter-Agency Committee (CBIAC) and completed under the aegis of the Pacific Northwest River Basins Commission. A Task Force for Puget Sound and Adjacent Waters was established in 1964 by the CBIAC for the purpose of making a water resource study of the Puget Sound Area based upon guidelines set forth in Senate Document 97, 87th Congress, Second Session.

The Puget Sound Task Force consists of ten members, each representing a major State or Federal agency. All State and Federal agencies having some authority over or interest in the use of water resources are included in the organized planning effort.

The published report is contained in the following volumes:

### SUMMARY REPORT

### APPENDICES

I. Digest of Public Hearings
II. Political and Legislative Environment
III. Hydrology and Natural Environment
IV. Economic Environment
V. Water-Related Land Resources
   a. Agriculture
   b. Forests
   c. Minerals
   d. Intensive Land Use
   e. Future Land Use
VI. Municipal and Industrial Water Supply
VII. Irrigation
VIII. Navigation
IX. Power
X. Recreation
XI. Fish and Wildlife
XII. Flood Control
XIII. Water Quality Control
XIV. Watershed Management
XV. Plan Formulation

# APPENDIX XIV
# WATERSHED MANAGEMENT

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## CONTENTS—Continued

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## CONTENTS—Continued



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## FIGURES

## CONTENTS—Continued

# SUMMARY


This Appendix is concerned with the management of watershed lands and water in order that damaged lands be restored in a timely manner and that future use of these resources of land and water benefit the economic and environmental needs of a growing population in the best way possible. In order to present these aspects of the Area, the Appendix necessarily concerns itself with actual and potential problems of management rather than the generally high existing quality found at this time (1969).

In the face of a projected population increase to 6.8 million by 2020 and resulting stresses on these resources, it is found that use of the land can be fitted to the resource and managed so that a high quality of environment can be maintained causing little conflict with economic growth. Conversely, lacking restraint and good management, great harm can come to these resources through exploitation, error, and waste.

These resources and their management needs are described in terms of present status, needs, and means to satisfy needs, and propose a plan of management for consideration with full knowledge that changes in needs and technology through the years will require details of the plan to be modified and updated frequently.

The Puget Sound Area includes all or parts of thirteen counties in northwestern Washington. Drainage is by ten large rivers, 12 smaller rivers, and numerous streams into Puget Sound, Georgia Strait, Hood Canal, and the Strait of Juan de Fuca. Within the 15,800 square miles of the Area are 2,430 square miles of salt water, 240 square miles of fresh water, and 13,130 square miles of land. The land has a particularly close relation to the water resource because of climatic, topographic, and vegetative characteristics.

The Area is divided into thirteen "basins" for detailed study purposes. This Appendix discusses many characteristics common to the basins under the Puget Sound Area portion of the report.

The Puget Sound Area has three topographic structural provinces: the Olympic Mountains on the west, the Puget Sound Trough, and the high Cascades on the east. Much of the central Puget Trough is below 1,000 feet in elevation, and most of the land suitable for farming and intensive development lies here. The Cascade and Olympic Mountain provinces are higher in elevation and largely in forest. Glaciation has influenced landforms below elevations of about 2,600 feet.

The native land cover is coniferous forest, and about 75 percent of the land surface is still occupied by forest growth. Croplands are found on low terraces and alluvial bottom lands. Lands best suited for farm use comprise about 6 percent of the land. Croplands are largely used for forage, vegetables, berries, and specialty crops.

Generalized land use (1964) is as follows:

| | Acres |
|---|---|
| Cropland | 591,500 |
| Rangeland | 106,400 |
| Forest | 7,039,200 |
| Rural non-agricultural | 238,900 |
| Built-up areas | 428,300 |
| Fresh water | 152,400 |
| Salt water | 1,555,500 |
| | 10,112,200 |

A climatic feature is the seasonal variation of precipitation causing dry summers and wet, generally mild winters. Precipitation results from cyclonic movement of marine systems. Orographic influences cause variations of precipitation with heavy winter accumulations of snow in the higher mountains. Several glaciers contribute summer flow to the larger rivers. Some small streams have very low flow during dry periods.

There are over 2,800 lakes, about half having surface areas less than five square miles. Twenty-four major impoundments have been constructed mainly for hydroelectric generation and water supply. Over 1,300 small ponds for rural water supply and recreational use are known to have been constructed. Few impoundments have flood control as their major purpose because of the large volume of flow during the winter flood season. A good supply of ground water underlies much of the bottom land area and is frequently utilized for rural use, including supplemental irrigation.

## Soils

Soils are a basic resource and possess a remarkable range of properties affecting hydrologic proper-

ties of watersheds as well as their suitability for production and adaptation to various developed uses. Each site condition for production or development imposes conditions related to the soil for protection under conditions of sustained use. Over 800 soil mapping units, based on the cooperative soils survey, have been described, measured, and interpreted for selected conditions of use. Exhibit 1 of this Appendix contains considerable physical and interpretative information to guide watershed management. A glossary of terms is included in the Exhibit.

Only low intensity soil surveys are available for lands within national park and national forest boundaries. Most of the land in non-Federal ownership has been covered with medium intensity surveys. There is a need to update some of the surveys and to complete high intensity surveys in parts of the Area to guide resource development and management. Needed surveys should be accelerated for completion by 1980. Estimated cost, including publishing, is $3 million.

## Watershed Rehabilitation and Protection Measures

An outstanding characteristic of the Puget Sound Area is that while erosion, under existing conditions, is nominal compared to many parts of the nation, the potential for erosion is very high. Serious damages from erosion and sediment production are prevented only by the generally excellent vegetative cover condition. When vegetation is disturbed in any way the disturbed land becomes a critical erosion area until the land becomes stabilized.

Much advantage is gained by careful selection of suitable areas for specific development of various kinds, followed by treatment measures in combinations selected to protect the land under the selected kind and intensity of use. About 1,352,000 acres have a moderate to severe erosion hazard, and 5,505,300 acres have a severe to very severe erosion hazard. The critical erosion area at any point in time consists of 138,000 acres newly disturbed each year by various kinds of economic activity; in addition to lands similarly disturbed each year by natural causes such as landslides, wild fire, floods, and stream channel erosion; and lands recovering from like disturbances of previous years.

Many watershed rehabilitation and protection measures are of a recurring nature and must be reestablished periodically and carefully maintained to be effective. The cost is largely borne by the landowner, and in the case of public lands by the land administration agency. The existing level of such practices satisfactorily maintained on the land is estimated to be about 40 percent of that required to meet the needs of future years. See Tables 2-15, 2-16, and 2-17 for estimated program costs by time frames.

## Sediment

Sediment is a by-product of erosion. Soil particles are detached, then moved by flowing water. Movement by wind is of localized importance in the Area. Large quantities of sediment are carried from the land each year. Only a small part of the gross erosion reaches stream courses and becomes part of the sediment delivery load. A general estimate is that at least 1,600 acre-feet of sediment delivery is achieved annually. Sources of this sediment are considered as follows: cropland, 9 percent; forested lands, 63 percent; rangeland, 2 percent; and all other lands, 26 percent.

Some sediment delivery is natural, but excessive movement causes many damages not fully understood or evaluated. Sediment accumulation in channels induces flooding, and sediment is recognized as an agent of pollution affecting many elements of the environment. Excess sediment causes large damages to streams, estuarine areas, and property. The classification of the kinds of sediment, its measurement, and its immediate and long-term effects on various ecological and environmental values is incomplete. A need exists in the Area for evaluation of damages and potential measures for damage reduction beyond the comprehensiveness and intensity now accomplished. A study is proposed for monitoring and evaluation, requiring cooperation between appropriate State and Federal agencies, at an annual cost of $150,000 for an extended term of years.

## Beach and Shore Erosion

The erosion of beach lands and shores of Puget Sound is continuing, and serious shore erosion conditions are found on 187 miles of Puget Sound coast. These are unique areas having large potential for recreation and other purposes. A study is needed to evaluate loss and probable means of control. The study will cost $500,000 over a period of several years, and corrective measures are estimated to cost $200 million by the year 2020.

## Flood Damage Reduction

Acreage subject to flooding has been estimated

on the basis of known flood history and geomorphology of soils. An estimated 747,000 acres are subject to floodwater damages of some degree at intervals more frequent than once in 100 years. Of this total, 276,800 acres are subject to overbank flooding of major rivers, in addition to other sources of such damage.

The area subject to damages (1969) consists of 190,800 acres of forested lands; 454,400 acres of cropland; and 101,800 acres of urban and rural non-agricultural lands. Damage from floodwater is estimated at $15,954,000 annually, of which $7,132,000 represents average annual overflow damage of major rivers.

The best cropland (about 6 percent of the land area) of the Puget Sound Area is located in alluvial flood plains, and the use of such hazard areas should remain in cropland or other open use to minimize the cost of protection and to limit the valuation subject to damages. Protection needed for croplands is against damage generally caused by floods recurring more frequently than once in ten years; and lesser degrees of protection are often of economic benefit. Many developed uses and urbanized areas require protection against floods recurring more frequently than once in 100 years.

Damage reduction is estimated as needed on 556,200 acres by the year 2020. Reduction of flood hazard is considered a prerequisite of investments for production efficiency on cropland or other economic development. The required degree of protection depends on the use of the land after development.

### Flood Control Measures

Flood control measures are structural measures on major rivers designed to prevent channel overflow onto adjacent lands. Appendix XII, Flood Control, specifically considers this source of damage and proposes 28 projects for early action, with additional projects in later years providing protection from overflow to 307,000 acres by the year 2020.

### Flood Prevention Measures

Flood prevention measures are described in Appendix XIV, Watershed Management, and consist of land treatment and structural measures to reduce floodwater damage. These measures provide damage reduction from tributary streams to flood plains and lands along minor streams. Twenty-five projects on small watersheds (less than 250,000 acres each) have flood prevention measures, in addition to drainage improvements and measures for other purposes, and are proposed for early action in Appendix XIV, Watershed Management. An additional 85 small projects are estimated to be feasible by the year 2020. The early action projects provide flood prevention benefits to 188,000 acres, in addition to other benefits at an estimated cost of $33,890,000.

Flood prevention measures are often complementary to flood control measures, and both types of measures are frequently required to achieve full potential damage reduction and development benefits. Full and timely achievement of these benefits in the early action program is best achieved by contemporary authorization of major flood control projects and small watershed projects containing flood prevention and drainage purposes, followed by timely installation of interrelated features. Flood prevention features are summarized in Table 2-20 of this Appendix and described in additional detail at the individual basin level.

### Cropland Drainage Improvement

Much cropland has had at least some degree of drainage improvement installed. In order to achieve the greater production efficiency required in future years, the degree of drainage must be increased on much of the land. Only land presently in crops is considered as part of the Puget Sound Area requiring improvement. To achieve potential production, 482,000 acres will require further improvement. In some cases protection from flood damage is a prerequisite for improvement. In many cases project-type community drains are required before investments in field drainage are practical. An average net benefit of $16.10 per acre has been attributed to drainage, but each site requires individual consideration. Drainage will largely be installed as an investment by the landowner where feasible outlets are available and where protection from floodwater damage adequately safeguards his investment. See Table 2-14 for estimated costs of drainage by basin.

### Urban Drainage Improvement

The area of urban development needing drainage is estimated on an average density of six persons per developed acre. Drainage of foundations and establishment of storm drains are deemed necessary to make the urban development practical. About 1,040,000 acres will require such work. The estimated cost averages about $33 per dwelling. The estimated cost does not include special outlet require-

ments which will vary widely, nor any aspect of sanitary facilities. A summary of estimated costs by basin is given in Table 2-14 of this Appendix.

## Irrigation

Irrigation is largely of supplementary character except in localized areas having low rainfall because of mountain rain shadow. The practice will become increasingly important as the needs of the Area require more production from less available cropland. In 1966 it was estimated 91,700 acres were irrigated.

Irrigation, like drainage, is installed mainly by individual landowners in response to a profit motive. Investments in irrigation will follow improvements that reduce hazards of loss due to flooding and poor drainage. A large amount of future irrigation will continue to be by individual initiative through pumping from ground water or diversions from small streams or storage.

A potential exists for project-type developments after 1980. A need for 396,000 acres of irrigation by 2020 is based on full development of cropland for production, expressed by Appendix IV, Economic Environment. Appendix VII, Irrigation, estimates 223,000 acres to be irrigated in 2020. The apparent deficiency of 173,000 acres of irrigation, if borne out by future events, translates into a future deficiency of production requiring increased import of food and fiber into the Area.

## Recreation

Only a relatively small amount of non-Federal land is specifically used for recreation. The multiple-use of privately-owned land and the multiple-use of Federal and State-owned lands furnish most of the ample recreational opportunity at the present time. There are about 4,160,000 acres of public lands available for recreational use. Recreation demand is expected to increase rapidly (Appendix X, Recreation).

There is a potential for development of private lands for recreational use for special purposes or in areas near metropolitan centers. A large potential for such developments will begin before the year 2000 and will create a demand for specialized facilities and services best provided through private enterprise. Reservoir sites and other natural features exist that may be developed for recreational appeal during future years.

## Fish and Wildlife Habitat

Present general status of habitat is much lower than in pioneer days. For appraisal of conditions see Appendix XI, Fish and Wildlife. Many opportunities exist for correcting limiting conditions and for protecting and enhancing the value of habitat in connection with projects for management of water and related lands.

## Municipal and Industrial Water

Generally adequate supplies of municipal and industrial water for development exist (1964). (See Appendix VI, Municipal and Industrial Water Supply.) Most of this water is diverted from streams and rivers. Storage in greater amounts will be required after 1980 for base needs as well as for balancing purposes. Opportunities exist for inclusion of capacity in large impoundments and for construction of small impoundments within multiple-purpose projects.

## Water Quality

Existing water quality is generally good to excellent. Watershed rehabilitation and protection measures assist in reducing sediment and sediment-related pollution. Rural areas are often served by local wells where potable water is available; however, many localities are supplied by distribution systems operated by public utility districts, municipalities, and others. Usual treatment is chlorination. More advanced treatment may be required in future years.

## Water Yield Improvement

No land is managed primarily for yield improvement at this time. A potential may develop on selected watersheds and associated snowfields after 1980. Management may include artifically induced precipitation as technology develops. A need exists to study potential for such development in specific adaptation to Puget Sound conditions. The study should be completed by 1980 and is expected to be financed by reorientation of on-going State and Federal programs.

## Lowflow Augmentation

Climatic, topographic, and soils conditions induce a low flow in many streams that greatly limit utility for many purposes. A need exists for study and development of watershed management measures

to improve summer flow. The study should be carried forward by cooperative efforts of State, Federal, and private interests largely by reorientation of existing programs. Large benefits would accrue to various purposes for improvement of this condition.

### Sediment Study Evaluation and Monitoring

A study, estimated to cost $150,000 annually, should be initiated to classify sediment according to physical, chemical, and biological nature, as well as to quantity; and to evaluate long-term effects of sediment production and movement on various economic, ecological, and other environmental qualities going beyond present efforts. The cost of a long-range monitoring and evaluation effort is expected to be a cooperative project between agencies of the State and Federal governments. The purpose is to investigate means for conserving and enhancing many environmental and economic values.

### Land Use and Treatment Study

This study is allied in part with the sediment study and will include in addition various economic and social effects on production, employment, and environment not presently fully evaluated. Means of describing and quantifying aesthetic features under Puget Sound conditions should be considered. Preliminary results should be available before 1980. The project is expected to be carried forward by cooperative effort of agencies of the State and Federal governments through acceleration and reorientation of on-going programs. The annual cost of acceleration is not estimated.

### Production

Development and adoption of improved technology for production efficiency under a sustained basis must be accelerated if production is to maintain its relative position in the face of a declining land base. A stable and viable farming and forestry enterprise is needed for the private sector to fully participate in measures aimed at better stewardship of land and water resources. This will be accomplished by acceleration and reorientation of on-going programs administered by various State and Federal agencies.

### Education

There is a need for an increase in numbers and betterment of preparation of graduates in technologies involving scientific agriculture and resource management conservation and development. A shortage of qualified graduates has been apparent during recent years. Information and incentives are required for increasing undergraduate and graduate participation in these fields, and for sustaining the educational plant to service these students. No cost is estimated.

### Information

Means must be found to inform and interest the urban resident in practical aspects of resource conservation and development, as well as to assist in the adoption of improved technology by land managers and administrators. Acceleration and reorientation of existing programs are required. No cost of acceleration is estimated.

### U.S. Department of Agriculture Program

Many of the program and project features of watershed management lie within responsibilities of the U.S. Department of Agriculture. Selected watershed management features are collected and presented as a USDA program emphasizing watershed rehabilitation and protection measures and projects for improvement.

The early action USDA program contains 25 projects for small watersheds deemed feasible on the basis of flood prevention and water management benefit. These projects, in addition, contain potentials for including specific features for recreation benefits, fish and wildlife habitat improvement, and water supply.

There is an urgency for installation of such measures because of rapid Area development; and for facilitating concurrent planning and timely installation of features interrelated with projects of the State and other Federal agencies. For these reasons the Secretary of Agriculture is expected to consider requesting Area-wide authorization of these projects and to enter into cooperative agreements with the State and with other Federal agencies to implement all parts of the program, including the special studies.

### Impacts of Watershed Management

The expected action of the Secretary of Agriculture outlined above, coupled with similar actions of other Federal agencies and the State of Washington, is expected to meet the urgencies created by rapid growth of population; result in orderly development; cause large savings in cost of public services and cost of opportunities foregone through inappropriate or unplanned development; and to greatly conserve and enhance many environmental values through the year 2020.

# INTRODUCTION

## PURPOSE AND SCOPE

This Appendix deals with management of the land and water resources, with particular emphasis on units of these resources called watersheds. The management is in the interests of flood prevention, land stabilization, prevention of pollution, and conservation of water for stream stability, and for the benefit of irrigation, drainage, and other purposes. In this discussion "needs" and "potential needs" refer specifically to the requirements of the people who inhabit the land. In this context, needs began with the first human inhabitant and increase with the numbers and sophistication of these inhabitants. The actions of these people have the potential to improve the natural environment for their needs or to destroy it. Needs range from the simple necessities for survival to include "wants" that, in truth, can be met in more than on way or degree or be temporarily foregone if required, and that change with social and economic conditions and with time and numbers of people. Production of the Puget Sound Area is a share of the National production and this production is expected to increase with time following National population growth.

Many of these needs and actions of the people lie in future years. This Appendix, therefore, first presents broad principles and consequences of management in the portion devoted to the present status of watershed management in the Puget Sound Area. This is followed by evaluation of needs; then means to satisfy needs in terms of feasibility of projects and programs estimated for the years 1980, 2000, and 2020. In a large measure management is derived from the interaction of people on their environment. Therefore, considerable attention is given to the inventory of the resources, largely derived from geomorphic, hydrologic, and ecologic considerations. Much of the data specific to individual basins and watersheds is presented in tabular form throughout the text, and important information for specific planning is contained in the exhibit following the main presentation.

The goal of the agencies participating in this study is the conservation, development, and maintenance of the land and water resources to meet the increasing needs of the people in the years to come. The challenge to the present and future inhabitants is to carry on into the next century the wisdom, restraint, and continuing study required to protect the favorable environment and use it for the good of all.

This Appendix on the management of watershed lands in the Puget Sound Area contains inventories and analyses used to support plans and conclusions presented in the Summary Report. Plans thus presented consist of programs and projects in the interest of meeting present and future needs by the best possible utilization and conservation development of the natural resources. This Appendix considers numerous separate but related factors concerning the care and use of the land resource, together with the resulting effects on water.

## LAND AND PEOPLE

Land is the resource base for nearly all human activity; the source of the direct and indirect products of farms, grasslands, forests, and mines. It is the space required for cities and towns, industries, ground transportation, wildlife, natural environment, and many aesthetic values, but in the sense of the physical geography of a region, the land is much more. It is the area that receives the precipitation, stores, and releases it for streamflow, and replenishes the ground water province.

The land area is a fixed quantity and must satisfy the diverse needs of the people for all time. Future developments will, in effect, depend upon how well the land can be used for the multiple-purposes of an expanding population.

The ability of man to change the land is steadily increasing. Earth-moving machinery can be used to remove the natural cover and make limited changes in topography. Roads and other transporta-

tion facilities change the accessibility of land with regard to population centers. Other changes, such as irrigation, may modify the climate; and covering the land with pavements and roofs will change runoff of water. Some of these changes are reversible, while other changes are, in a practical sense, permanent. The available land ranges over a wide spectrum of elevation, topography, climate, vegetative productivity, and permeability. Good judgment dictates that land for various types of development be wisely chosen and carefully developed and treated, so that irreversible changes are not needlessly induced in critical areas or without full consideration of the consequences. The difficulty lies in the practical fact that the consequences of unwise development or development methods may not become apparent at once but may induce chain-like changes in the environment that will persist long after the act and contribute greatly to the cost of opportunities foregone for those who follow.

Lands vary widely in their ability to accept development from the natural condition into intensive use by man. Some areas have the capability to accept given changes with minimum damage to the stability of the soil mantle or to the hydrologic cycle. Other areas are critical and disturbing them by development may result in widespread damages, both within and outside the area. Every such developed area thus has certain minimum needs for treatment and maintenance in order to allow continued use in the developed situation. The treatment and maintenance are costs required for developed use. These minimum requirements or costs are tolerable in some areas and for some uses and prohibitive in others, and these factors are constraints on development. The public is an interested party to changes in land use and consequent treatment, for many of the costs are directly or indirectly borne by the public and the losses or benefits from the development become secondary losses or benefits to all the people.

The dramatic expansion of urban-type developments, highways, and other construction since World War II causes concern about increasing sediment loads that reach the rivers, streams, lakes, reservoirs, and estuarine zones from various forms of resource exploitation. A study is warranted to determine long-term effects of sediment production movement and deposition in the Area and to determine the best means for remedial measures. Much of the best agricultural land is threatened by urban expansion and by conversion to doubtful land uses around cities. This results in increasing pollution and other damages, including the loss of environmental values.

During these years, there has been a significant migration of people to the cities and a contemporary loss of rural-based population. But the people in the cities have not escaped the land; urban people in many ways become more dependent on watershed decisions than when the population was relatively dispersed in the rural environment. An unhappy aspect of this arrangement is that the city dweller often has less intimate knowledge of conditions, and less opportunity to directly participate in land management decisions, by reason of being further separated from the land than his rural counterpart.

The city dweller, then, must learn about the land and must find means to delegate and encourage good land management by private enterprise and by the various forms of government if the land and water resources are to be used to achieve the greatest benefit. Private land management must be provided a continuing opportunity to share in economic gains from the productive uses of land, for only in this way–by incentive–is good management possible.

There is no shortage of land or water, as far as can be predicted, provided the best use, the wisest allocation, development, and treatment measures are applied. The matter of the use of environment is too important to leave to chance. A rational alternative should be developed to cope with urban congestion and suburban sprawl, leaving sufficient space in the countryside for those who choose to live and work in a rural environment. Uneven distribution of opportunity, whether it be rural or urban, is a part of the total conservation management problem and has an important bearing on the future successful management of the physical resources of the Area. The reader may recognize this as a significant part of the fundamental long-term problem that includes not only the question of what man is doing to his resources but, conversely, what will the environment do to and for man.

## THE WATERSHED

The watershed is a unit of land that catches precipitation and serves to move and concentrate water at some lower elevation. Watersheds are termed catchments by some people, and by others are

considered to represent only the topographic divide between neighboring drainage basins.

The most easily visualized watersheds are those occurring in the upland topography of Western Washington where streams are deeply incised and divides are distinct. In southern Pierce County, the watershed may be subterranean and a divide is not easily visible on the surface. In brief, all land is watershed land that is capable of yielding water, either as surface runoff or as subsurface flow.

The extensive dissection of land by rivers and streams and the smallest rill permits one to question where a watershed begins and ends. River basin and watershed planning by different agencies of government, and the delineation in Federal law of what are thought to be small watersheds at 250,000 acres, have complicated usage of the term "watershed." The size of a watershed depends on two factors: the natural occurrence of watershed boundaries, and the necessity for delineating small or large watersheds from the standpoint of water control or other forms of water management. Thus, depending on the purpose of the study involved, a watershed can be the size of the largest river basin down to watershed areas an acre or less in size.

A more specific interpretation of watershed size should be made from the standpoint of land management. The extent of local development and management practices and the effects of these practices will determine the watershed area to be encompassed, and will also determine the scope of watershed management. The manager normally applies specific practices on small land areas or watersheds; in other words, attention is often focused on the smaller recognizable ecological complexes. Every facet of land–soil, geology, vegetation, climate, slope, and aspect–may have a different effect on water yield or soil erosion. Therefore, emphasis in watershed management should be placed on small watersheds that closely fit the application of specific development practices. The small watershed always will be important, whether emphasis in management is on water yield control or watershed protection.

As stated, emphasis on small watershed areas does not imply that watershed management is restricted to the small watershed. An individual management unit may have consequences on streamflow far downstream, and the cumulative effect of individual units in the subtributaries of a larger watershed may be even greater. For example, cull logs from a timber-cutting area may wash into a main stream, jam up, and cause a bridge and road washout following an unusually intense storm. The cumulative effect of silt production may cause the entire watershed behind a dam to be of significance. It is the downstream effect which extends the size of the watershed as it relates to the scope of watershed management and also poses the most perplexing problems for land managers, now and especially in the future.

In this Appendix, areas of land within the river basins are designated as watersheds for discussion purposes and are shown on the accompanying maps. The reader should recognize that the watershed boundaries thus located are somewhat arbitrary concessions to a practical presentation. Each such designated area contains many smaller watersheds that might require individual consideration for some levels of management.

## MANAGEMENT OF THE WATERSHED

The scope of the subject gives rise to various technical definitions of watershed management but all generally agree that the land and related water resources are the ingredients to be managed, and that good management is to result in a favorable influence on the water produced from or utilized in the watershed. This requires that the land be used within its capabilities and treated according to its needs under the uses decided upon, and that the water itself be managed to prevent damages to the resource and to achieve the desired benefits.

The objectives are to protect the land against all forms of soil deterioration; to rebuild eroded or depleted soils; to build up soil fertility; to stabilize critical runoff and sediment-producing areas; to improve grasslands, woodlands, and wildlife habitat; to conserve water for beneficial uses; to provide needed drainage and irrigation; and to reduce flooding, swamping, sediment, and pollution damages. These objectives can be attained by the application of land treatment practices and by building water control structures on individual farms and upstream

drainageways through both individual and organized action.

Information has accumulated over many years on the hydrologic behavior of land; i.e., the relationship between the kind of land, its use and treatment, and the water yield and streamflow. There is now a basic understanding of the relationship between the land and runoff, water yield, debris deposition, pollution, shoaling of stream channels, silting of reservoirs, storm flows, and other adverse effects that have followed excessive logging, construction operaions, and fires.

Among the hydrologic functions of vegetative cover are breaking the impact of rainfall, direct interception of a part of the precipitation by aerial portions of plants, dissipation of moisture by transpiration and evaporation, and binding the soil against erosion. A highly beneficial effect of vegetal cover is that of building up and maintaining the organic content of the soil, thus greatly increasing the infiltration and storage capacity of the soil within the root zone. Likewise, the maintenance of a cover of undecomposed and partly decomposed organic matter on the surface of the soil tends to prevent erosion and protects the pores of the soil from being blocked to the passage of water. The mechanical effect of stems and roots serves to keep the water spread over the surface of the land, prevents formation of gulleys and retards runoff so that water moves more slowly, allowing more time for absorption. Trees and other ground cover shade the ground and minimize wind movement, thus reducing and stabilizing snowmelt rates and serving to lessen rapid runoff and promote infiltration.

Such variables as climate, geology, and topography, may not be effectively improved for watershed management purposes by man's activities but the use of land and the manipulation of vegetation can be accomplished with comparative ease. Watershed management, then, is to a considerable extent the management of vegetation and the soil mantle, thus providing a degree of control over the rate, amount, timing, and character of runoff; in turn influencing water production, water quality, floods, swamping, and land stability.

Most watersheds in the Puget Sound Area contain a mosaic of land types on which a variety of uses may be in progress, including forest, cropland, urban, transportation systems, and others. All of these uses of land can modify, and probably have modified, the hydrologic functioning of the watershed. For example, the acres of concrete, asphalt, and roofing within an urban area do not permit optimum infiltration of water into the soil so that more and quicker runoff will occur, thus contributing to flood peaks. To a greater or lesser degree, the rainfall-runoff relationship may be modified on other types of land and by other uses.

Watershed management is "tied" to the land and consequently the objectives of watershed protection and water yield control are accomplished through methods and institutions that are used to manage land. Increases in erosion, flood peaks, or water yield may occur as a consequence of a number of land use practices or natural phenomena. Timber harvesting on forest land is one of these important uses. Other uses or natural occurrences are wildfires or controlled burning on forest, range, or farm lands; grazing; farm cultivation; highway and airport construction; and housing developments. Land use per se may so modify soil, vegetation, and waterways that the Area will never perform the same hydrologic function as before, or the management may only modify conditions temporarily and natural water control may return.

Watershed management for control of erosion, floods, or water yield is a matter of evaluating the way in which management practices are carried out and then modifying them, if necessary and possible. The responsibility rests with the landowner and with delegated managers. Consequently, the forester, the farmer, and the city manager or engineer have the maximum responsibility for applying watershed management. In this State, so predominately in forest land, the forester's role is substantial.

All types of land, and all uses of land, may be implicated in the broadest type of watershed management if they measurably affect the water cycle, erosion, or water quality. Watershed management includes vegetative management as an important and fundamental aspect of the work but also includes certain classes of water management structures that serve to supplement vegetative controls for increased effectiveness or security or are for the purpose of developing optimum benefits from management. Many other kinds of water management structures benefit from good watershed management but do not in themselves contribute to the management of the watershed area.

Puget Sound basins yield large quantities of good quality water, but there are large seasonal variations in flow. Heavy winter flows are frequently

damaging and cause considerable bank erosion and sediment movement, as well as other damages. Summer flows may be so low as to cause some shortages of water except in the large rivers. Seasonal variations may be more pronounced in the smaller tributaries. Rapid development of the Area, especially along the eastern shore of Puget Sound, has intensified interest in all aspects of long-range water planning and will bring increased demands on the water supply.

Land in, or close to, its natural condition has numerous interrelated characteristics that are the result of many centuries of conditioning to the environmental factors of climate and raw geologic materials. Some of these characteristics are topography, vegetative cover, soil mantle, etc. Features such as soil mantle stability, permeability, and water-holding capacity are thus in a delicate dynamic balance between the forces of nature–a balance reached somewhat by trial and error over long periods of time.

Because of the importance of this balance, much of this discussion is based on this complex relationship. This is especially true of the relationship of soil and vegetation to water and of the means by which this relationship can be improved to increase the productivity of the land for agricultural purposes or to more adequately adapt it to urban-oriented developments of various kinds. Where these relationships are ignored, there is greatly increased soil erosion, loss of mantle stability, and changed hydrologic conditions that can result in grave problems of pollution, swamping, drought, and sedimentation.

The general mechanism of erosion and the subject of drainage and other water control related to conditions of land and its use are discussed. Drainage methods are discussed in terms of the results to be obtained and the techniques and difficulties in collecting and disposing of excess water. The role of soils in drainage activities is examined in terms of amounts, locations, needs, and means for improvement.

Certain phases of water management are covered in Appendix XII, Flood Control, which treats primarily the overflow flooding from principal streams, and Appendix VII, Irrigation, which is concerned mainly with the application of water to increase agricultural yields. These subjects are not repeated here except as they relate to land stability, watershed management, and drainage. Water supplies for domestic and industrial use are discussed in Appendix VI, Municipal and Industrial Water Supply, and in Appendix XIII, Water Quality Control, and are not treated here except for certain factors of pollution by sediment and open land use. Similarly, needs and effects on recreation and fish and wildlife habitat are covered in Appendix X, Recreation, and Appendix XI, Fish and Wildlife, respectively, but the reader will recognize the impact of sediment and uncontrolled waters on these resources and many others.

## STUDY METHOD

Published and unpublished soil surveys were evaluated, and soil mapping units were measured by subwatershed, watershed, and basin areas. The areas lacking surveys were evaluated using best available resource information, consisting generally of unpublished data, or other information furnished by land management agencies. The resulting compilation is believed to be the best possible, short of additional detailed soil surveys. Lands thus measured were grouped in various ways by physical properties to facilitate interpretations of suitability for various uses and to determine treatment needed for stability under use.

An inventory of land use was derived by planimetering results of field investigations recorded on 1965 aerial photographs at a scale of two inches to the mile, supplemented as necessary by other contemporary photography and land management agency records. Use was taken as the purpose rather than the strict ecological condition; for example, forested areas devoted to housing developments were measured as "built-up" areas rather than forest. Six generalized categories of use were measured: urban, forest, cropland, rural non-farm, range, and inland water. Acreages thus obtained do not entirely agree with census data or data prepared for other purposes but give a better indication of actual use of the land.

Generalized ownerships, where shown, are from

county records or published atlases of ownership which lag somewhat behind actual transfers. Acreages thus obtained, while suitable for general planning, should not be used for detailed work and may not agree with records kept for legal or tax purposes which are outside the scope of this discussion.

All measurements were tabulated by automatic data processing methods. The tabulations are the result of measurements, and the acreages by basins and in total agree closely with tabulations made for other purposes. No effort has been made to adjust acreages to agree with tabulations prepared for other purposes because of the difficulty in adjusting each of the many subtotals and because the adjustment would have no significance in land management planning.

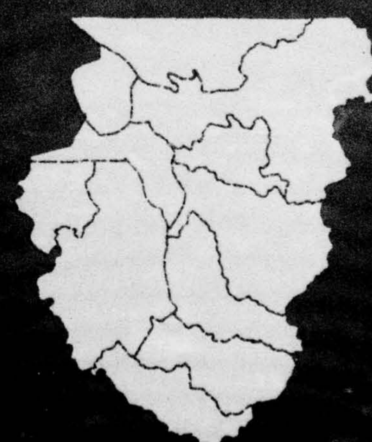
Damages from flooding are based on average annual cost records prepared by the Flood Control Committee and extrapolated as required for tributary areas where experience records are unavailable. Areas of tributaries subject to flooding where records are unavailable were taken as alluvial soils with 0-3 percent slope.

Wet conditions were estimated by geomorphologic data associated with the soil survey and adjusted to generalized land use through consideration of physical evidence and local information. Evaluations of watershed areas were also used to extrapolate an estimate for watersheds where no detailed information on probable benefits was available.

The cost of cropland drainage was obtained by using local costs applied to the drainage experience grouping of soils. Cropland benefits were estimated in a similar manner, using experience budgets of similar lands before and after drainage; the difference in net income being credited to drainage. Forested lands were considered as not requiring drainage. All urban and most rural non-agricultural lands were considered as requiring drainage and water disposal facilities due to disturbance of the hydrologic pattern and the high property values to be protected. Costs of urban drainage were derived from typical experience and extrapolated to future land requirements estimated by the Land Use Committee.

Land treatment measures for land stability are derived from the capability classification of soils under projections of land use derived by the Land Use Committee. Needs for cropland irrigation and other water management are also from the Land Use Committee, and projections by the Regional Economic Studies Technical Committee.

# Puget Sound Area



# PUGET SOUND AREA
# PRESENT STATUS AND POTENTIAL

## THE LAND RESOURCE

### PHYSIOGRAPHIC SETTING

Within the 15,800-square-mile area designated as the Puget Sound Study Area (see Figure 2-1) are striking contrasts in types of terrain, resulting in wide variations in the Area's water resources. The lowlands contrast markedly with the mountains of the Olympic and Cascade Ranges which form the Area's western and eastern borders. A low divide forms the southern border, separating Puget Sound drainages from the Chehalis River Basin.

Puget Sound itself is an attractive inland sea providing a marine setting for a large part of the Area and containing the deep-water harbors of its principal cities. The salt water area of about 2,400 square miles is characterized by numerous channels, bays, and inlets. South of Admiralty Inlet, the principal entrance from the Strait of Juan de Fuca, the Sound branches into Hood Canal, a long, narrow body of water extending southward about 50 miles near the base of the Olympic Mountains. Between Puget Sound and Hood Canal is the Kitsap Peninsula, an area of 582 square miles, that lies mostly below an altitude of 500 feet. On the peninsula, as on the islands of the Area, available water resources consist of small streams and ground water.

Alluviated river valleys, with broad floors bordered by steep hills, constitute an important physiographic feature of the Puget Sound lowlands. The lowland valleys, with their mountain-valley extensions, contain most of the population, industry, and farming. The main rivers of the Area, descending from mountainous headwaters, course through the valleys to meet the salt water of Puget Sound in tidal estuaries. The valleys are separated by plateaus, the gently rolling surfaces of which are altered segments of a plain that formerly was continuous. Terraces, lakes, and marshy depressions diversify the terrain on the plateaus. In much of the Area, the transition from broad, hilly lowlands to mountains is rather abrupt.

In the Cascade Range, which flanks the eastern part of the Area, the principal rivers head at altitudes where precipitation is abundant and where large amounts of snow accumulate each winter. The higher ridges generally reach an altitude of about 8,000 feet in the north and 5,000 feet in the south. Rising prominently above the rather uniform summit levels of the Cascades are the inactive volcanoes of Mount Baker (10,778 feet), Glacier Peak (10,541 feet), and Mount Rainier (14,410 feet). The 27 named glaciers on Mount Rainier constitute the most extensive glacier system of any peak in the contiguous United States. However, farther north in the Cascades, glaciers are more prevalent than at the latitude of Mount Rainier. The alpine country of the North Cascades, with its many rugged peaks, glaciers, and wild rivers, is an area of spectacular scenic beauty.

The Olympic Mountains, on the west side of the Area, are similarly rugged and scenic. They are generally at a lower altitude than the peaks of the North Cascades. Within Olympic National Park is a complex system of deep valleys and canyons, separated by sharp ridges and peaks that commonly attain altitudes of 6,000 feet. In contrast to the Cascade Range, there are no volcanic peaks in the Olympic Mountains. The headwaters of the largest rivers originate at glaciers and snowfields of the major peaks. On the north, relatively narrow, hilly lowlands lie between the Olympic Mountains and the Strait of Juan de Fuca. On the east slope, where the descent from the mountains to Hood Canal is abrupt, the only significant water resource development is in the Skokomish River Basin.

Within this setting, the development and use of the land requires careful attention to the protection of water and soil values. For a desired level of watershed management, the major factors to consider include climate (particularly precipitation), geology, topography, soils, and vegetation.

#### Climate

Because most of the air masses that reach the Puget Sound Area originate over the Pacific Ocean, the climate of the Area is predominately a mid-latitude, west coast, marine type. The maritime air has a moderating influence in both winter and summer; it produces a well-defined rainy season in winter and a dry season in summer with considerable

orographic variation. Only occasionally does dry continental air from the north or east reach Puget Sound.

Terrain, position, and intensity of the high and low-pressure systems over the North Pacific, and westerly winds, as well as distance and direction from the ocean, have an influence on climate. To the east, the Cascade and Rocky Mountains shield Western Washington from cold winter air masses traveling southward across Canada. To the west, the Olympic Mountains and the Coast Range on Vancouver Island effectively protect this area from the more intense winter storms reaching the Coast. The Strait of Juan de Fuca, Strait of Georgia, and the Chehalis River valley provide low-level passages for maritime air moving inland.

## Geology and Topography

The Puget Sound Area has three topographic structural provinces which are, from west to east: the Olympic Mountains, the Puget Sound Trough, and the high Cascades (see Figure 2-1).

**Olympic Mountains Province**–The Olympic Mountains province comprises the whole central part of the Olympic Peninsula that lies on the west side of Puget Sound. The mountains are extremely rugged, comprising a complex system of valleys and canyons with intervening ridges and peaks that commonly attain altitudes of 6,000 feet. The descent on the east slope to Hood Canal is abrupt.

The core of these mountains is composed of bedded rocks consisting of slates, argillites, sandstones, and schists. All of these rocks, originally marine sediments, were uplifted. Wrapped around the core, and open to the west, is a thick sheath of basalt flows and tuffs, erupted under water, and now more or less altered to greenstone.

There is no granite in the bedrock of the Olympic Range; however, abundant boulders of granite and other "foreign" rock types lie on the ground up to elevations of 3,000 feet across the north face of the mountains. These boulders were deposited during the melting of glacial ice during Pleistocene time.

**Puget Sound Province**–The Puget Sound province lies between the Olympic Mountains on the west and the Cascade Range on the east. It consists of a depressed area, mostly below 1,000 feet in altitude. It is occupied in part by the intricate reaches of Puget Sound, Admiralty Inlet, and Rosario, Haro, and Georgia Straits.

In the past most of the Puget Sound province was completely buried under glacial deposits from the north. The land under the Puget Sound has sunk about 1,000 feet. Where the lower present-day rivers flow into the Sound their estuaries have been silted up to form rich farmlands.

Throughout the Puget Sound province the bedrock consists largely of Tertiary sedimentary formations and associated lavas. However, erosion has cut through these formations, exposing here and there the Paleozoic and Mesozoic metamorphic rocks beneath. The San Juan Islands are examples of exposed older formations.

**Cascade Province**–The Cascade Mountain Range province lies on the east side and parallel to the Puget Sound province. It reaches an elevation of about 8,000 feet in the higher ridges. The many large rivers and their innumerable tributaries have dissected the mountainous area into deep valleys, canyons, and ravines.

The intermittent volcanic activity throughout Pleistocene and Recent times appears to be partly postglacial. All volcanoes were initiated on a topography that was already very rough and mountainous. Glacial features of the Cascades include the filled estuaries along Puget Sound.

The rocks of the Cascade Mountains are chiefly Paleozoic and Mesozoic sedimentary and metamorphic types. Thousands of cubic miles of the granitic rocks were formed at some considerable depth below the older compressed rocks, then raised up into a mountain range high enough that their cover was eroded away.[1]

The sediments from erosion of the Cascade and Olympic Mountains, and the glacial material from the north, are the parent materials from which most of the soils at the lower elevations of the Puget Sound province formed. The parent materials of the soils at higher elevations of the Olympic and Cascade Mountains consist mostly of sedimentary and igneous rocks and volcanic matter.

Under natural conditions, the surface of these raw rock materials, sediments, and volcanic matter, is covered with a friable mantle of soil–a great natural resource–that is the result of centuries of physical, chemical, and biological forces acting on the parent materials.

[1] Campbell, Charles D., Division of Mines and Geology, Washington Department of Conservation, Washington Geology and Resources, Information Circular 22R. 1962.


**FIGURE 2-1. Generalized geologic map of the Puget Sound Study Area**

### Ecology

The native land cover of the Puget Sound Area is dominated by a dense growth of conifers. Grasslands and open park-like areas occur where local soil-moisture-temperature relationships, history of use, or frequent fires favor grasses more than trees.

Since the glacial epoch, the Area has experienced several climatic cycles which affected the vegetation. Evidence seems to suggest the period of maximum temperatures occurred between 8,000 and 4,000 years ago. Changes in temperature and moisture conditions, natural forest succession, and possibly disease, may have influenced the vegetative changes from forests of white pine and lodgepole to other species.

Perhaps the most detailed study of postglacial forest succession has been made by Hansen,[1] using the Mount Mazama pumice sediments and other sediments containing pollen as principal dating benchmarks, together with other evidence. The climate and chronology data shown in Figure 2-2 come from his work. More recent studies based on carbon 14 dating techniques have modified the absolute dates somewhat, but the chronological order is essentially unchanged from that given.

## LAND COVER

The Puget Sound Area suports a dense, natural vegetative cover as a result of the prevailing maritime climate. Before the white man came, the Area was almost wholly blanketed by dense, coniferous forests which still occupy over 75 percent of the total land area. Forests, composed mainly of Douglas-fir, western hemlock, western red cedar and associated species, occur mainly in the wetter mid-elevations. The lowland areas surrounding Puget Sound are carpeted by a large variety of herbaceous and woody vegetation, including scattered stands of hardwoods and second-growth coniferous timber. Grass prairie-like areas occur at numerous locations in the southern and western sectors of the Puget Sound Area. The higher elevations in both the Cascade and Olympic Mountains contain a typical alpine ground cover interlaced by numerous and extensive rock barrens.

Vegetative cover of the prairie-like areas consists primarily of grasses. However, scattered stands of Douglas-fir and Oregon white oak are common. Scotch-broom has now invaded parts of the open areas.

The vegetative cover of poorly drained mineral soils consists of western red cedar, western hemlock, red alder, willow, and black cottonwood. The understory consists of evergreen blackberry, spirea, oceanspray, wild rose, skunk cabbage, and tules.

Sedge and woody peat bogs have vegetative cover consisting of western red cedar, spirea, oceanspray, evergreen blackberry, sedges, and tules. Vegetative cover of sphagnum peat bogs consists of living sphagnum moss, Labrador tea, low-bush cranberries, swamp laurel, and scattered stands of logdepole pine.

Tidal flats have a salt grass cover and fresh water marshes commonly have cover consisting of tules and sedges.

On the alluvial flood plains or bottom lands, vegetative cover varies with the degree of soil drainage. Generally, the poorly drained soils with water tables of less than five feet have western red cedar or mixed stands of western red cedar, western hemlock, Douglas-fir, red alder, and bigleaf maple.

Aside from productive values, the principal value of cover is in the protection and stabilization of the soil. Vegetation shields the soil from the beating action of raindrops. It maintains or improves soil infiltration capacity and permeability. Plant roots bind the soil, increasing its stability against movement by gravity, wind or water. The organic litter beneath the cover has a sponge effect, holding some moisture, and slowing the movement of what it cannot hold. As the litter decays and becomes incorporated with the soil, it improves soil structure, both in porosity and in moisture-holding capacity.

Plant roots penetrating the soil body also increase soil porosity and provide additional means of temporary storage and transmission of moisture within the soil. Thus, the extent and condition of the cover is a major factor governing the quality of water produced from a given watershed area, and the way the water runs off the area.

In addition to its affect on water quality, vegetation influences the amount of water produced to a considerable degree. Plants are themselves users of water. The amount of water yielded from a watershed under vegetative cover is dependent on a large number of factors which can be summarized into two concepts: (1) the amount of precipitation, and (2) evapotranspiration. Precipitation is the input

[1] Hansen, H.P., Postglacial Forest Succession, Climate, and Chronology in the Pacific Northwest. Trans. Amer. Phil. Soc. 37: 1-30. 1947.

**FIGURE 2-2. Postglacial climate and forest succession**[1]

| Years ago | | | ASH and PUMICE | CLIMATE PACIFIC NORTHWEST | PUGET SOUND |
|---|---|---|---|---|---|
| 1000 | POSTGLACIAL | LATE | | | HEMLOCK PRE-DOMINANCE AND MAXIMUM |
| 2000 | | | | PERIOD IV<br>COOLER-MOISTER | Douglas fir slight decline |
| 3000 | | | | | White pine and lodgepole static<br>Fir static |
| 4000 | | MIDDLE | Devil's Hill pumice | | Hemlock rapid rise |
| 5000 | | | Willamette Valley pumice | PERIOD III | Douglas fir decline<br>White pine slight rise |
| 6000 | | | Washington volcanic ash | MAXIMUM | Lodgepole pine static |
| 7000 | | | | WARMTH and DRYNESS | Douglas fir slight decline |
| 8000 | | EARLY | | | White pine minimum<br>Lodgepole static |
| 9000 | LATEGLACIAL | YOUNGER | | | Hemlock slight expansion<br>Fir static |
| 10000 | | | Mount Mazama pumice | PERIOD II | Douglas fir predominance |
| 11000 | | | | INCREASING WARMTH | DOUGLAS FIR PREDOMINANCE AND MAXIMUM |
| 12000 | | | | and | Fir static |
| 13000 | | | | DRYNESS | Hemlock expansion arrested<br>Lodgepole rapid decline |
| 14000 | | | | | DOUGLAS FIR RAPID RISE TO SUPERSEDE LODGEPOLE PINE |
| 15000 | | MIDDLE | | | Hemlock slow rise |
| 16000 | | | | PERIOD I | Lodgepole rapid decline |
| 17000 | | | | COOL<br>MOIST | Douglas fir expansion<br>White pine maximum |
| 18-20000 | | | | | LODGEPOLE PREDOMINANCE AND MAXIMUM |

1 Hansen, H. P., "Postglacial Forest Succession, Climate and Chronology in the Pacific Northwest." Trans. Amer. Phil. Soc. 37: 1-130, 1947. (Adapted from table 9.)

into a watershed; without it, there would be no streamflow. Evapotranspiration is the water leaving the watershed in the form of vapor. It occurs from plant, soil, rock, and other surfaces in response to atmospheric energy. The relationship of these two factors is demonstrated schematically in Figure 6, in the section on Land Stability.

In the Puget Sound Area, the major part of the water loss through evapotranspiration is due to the influence of vegetation. While there is a lack of data specifically applicable to the Puget Sound Area, the available information indicates that the annual water yield from well-forested watersheds approximates 60 percent of the annual precipitation. The remaining 40 percent of the precipitation is mainly lost through the various processes of evapotranspiration. Vegetation alone uses some 30 percent, or about one-third of the total annual precipitation.

Complete removal of the vegetation should result in greatly increased water yields, a statement that is generally borne out by observations in areas where this has occurred. However, cover removal causes more problems than advantages. Plant cover requires a part of the water resource in making its own growth but where there is no cover, or inadequate cover, there is too much water at some seasons and not enough at others. Floods alternate with drought, and the water produced is too turbid and sediment-laden for use. It is to be noted that this is precisely the situation that occurs following widespread forest, range, or brush fires, the results of which are commonly known. These results are the direct effect of widespread cover removal.

While widespread cover removal normally is not desirable for a variety of reasons, there is considerable opportunity for the improvement of water yields through other methods of cover manipulation. Experiments in the modification of forest cutting patterns; in cover-type conversion, particularly the reduction of heavy water-using plants; or in snowpack management, have shown that water yields can be significantly altered. Obviously, such programs must be carefully planned with specific objectives in mind..

## LAND USE

Land use has greatly affected the composition of the cover. Much of the lowland area has been cleared for urban, suburban, industrial, or agricultural uses. These bottom lands are largely used for intensive production of grass for dairy cattle, or for other crops such as vegetables or berries. Some land has been cleared on the benchlands or moderately rolling uplands and this, also, is dominantly used for the production of forage for livestock enterprises. Other lands, primarily the upper benchlands, foothills, and the mountains, remain in forest. Much of the timber has been harvested and is in varying stages of regrowth, or is in non-commercial categories.

The natural soil-cover hydrologic balance is usually well maintained in that a large portion of the cropland is devoted to forage production while the foothill and mountainous areas remain in timber and brush. The lowland areas, and much of the higher benchlands, were logged extensively during the past century. Brush is found in some areas that have been logged and burned repeatedly. Croplands generally occupy main stem, primary, and secondary stream bottom lands and glacial terraces; however, rural non-farm and urban areas are encroaching upon these lands (see Figure 2-3, Generalized Land Use map). Forests occupy steeper slopes at the higher altitudes.

Land used for crops in the Puget Sound Area totals approximately 591,500 acres. About 75 percent of this is in rotation grass for livestock and the remainder is in vegetables, cane fruits, and specialty crops. Forest, together with associated open areas, covers approximately seven million acres. Water and other uses combine to account for the remainder. (Refer to Table 2-1.) A summary of land use by basins, and definitions of the various uses, may be found in Exhibit 1.

**TABLE 2-1. Present land use, Puget Sound Area**

| Class | Acres[1] |
|---|---|
| Cropland | 591,513 |
| Rangeland[2] | 106,448 |
| Forest[3] | 7,039,184 |
| Rural non-agricultural | 238,854 |
| Built-up areas | 428,330 |
| Fresh water | 152,444 |
| Salt water | 1,555,500 |
| Total | 10,112,273 |

[1] Unadjusted measurements, 1966, for Puget Sound Area Study, surveys recorded on 1965 aerial photographs; tabulations by ADP (Automated Data Processing). Accuracy to three significant figures.

[2] Unplowed, unimproved grasslands.

[3] Includes non-forested grass, brush, and barren land commonly associated with forest.


FIGURE 2-3.

PUGET SOUND AND ADJACENT WATERS
STUDY AREA

Generalized Land Use

# SOILS OF THE PUGET SOUND AREA

The sediments from erosion of the Cascade and Olympic Mountains, and the glacial material from the north, are the parent materials of most of the soils at the lower elevations of the Area. The parent materials of the soils at higher elevations of the Olympic and Cascade Mountains consist mostly of sedimentary and igneous rocks and volcanic matter. The soil at any site is the result of centuries of physical, chemical, and biological forces acting on the parent materials.

The soil mantle is of special significance because of its many functions. First in importance is the function of growth of vegetation. This growth is the source of food and fiber for consumption as well as an important element in preventing soil movement and loss. The soil mantle is widely used as a disposal area for waste materials. It is the habitat of many kinds of helpful bacteria and wildlife. The permeability of the soil and its ability to retain water are of great hydrologic importance. The stability of the soil is of further consequence since soil erosion is the source of sediment. The soil mantle is the foundation of many structures and soil itself is a common material of construction for many structural improvements. The nature and treatment of the soil determines how well these various functions are served.

## FORMATION OF SOILS

Materials from which soils of the Area are derived are considered in four broad categories. They are: (1) materials weathered from intrusive, extrusive, and sedimentary rocks; (2) glacial sediments; (3) lacustrine deposits; and (4) organic deposits.

The parent rock materials that have contributed to soil formation in this Area consist of graywacke, slate and limestone of the Paleozoic Era; granite, arkose sandstone, argillite, mica schist, conglomerate and serpentine of the Mesozoic Era; sandstone, shale, andesite, and porphyritic basalt of the Eocene Epoch of the Cenezoic Era; and siltstone , sandstone, and basalt of the Miocene Epoch of the Cenezoic Era. Areas lying below 2,600 feet elevation were modified by glacial scouring and mixing of parent rock materials during the Pleistocene Epoch of the Quaternary Era. The Vashon glacier and many local mountain glacier advances and recessions of the late Wisconsin Glacial Period deposited varying depths of mixed glacial alluvium over bedrock. Many kinds of rock, volcanic ash, and pumice are the parent materials for stream bottom lands and terrace soils.

Glacial materials are classified as basal till and ablation till. Basal till consists of compacted or cemented materials, whereas ablation till consists of loose outwash sand and gravels. Flood plain or alluvial soils were formed in soil materials which eroded from upland areas, carried by floodwaters, and deposited in the valley floors. Some soils have formed at elevations above the glacial influence. Organic soils have their source in closed glacial basins and shallow slack water stream channels and bays. In these basin areas remains of plants, minute marine organisms and their excreta have accumulated under water where disintegration and decomposition have been relatively slow. Organic soils in this area have accumulated at the rate of about one inch in 40 years.

Relief or topography has an important bearing on the rate of drainage and on erosion, as well as on climate. Water drains slowly or not at all from the basins and depressions. In such areas a large amount of available water encourages the growth of plants that require ample water. These are the areas where reeds, sedges, and mosses have accumulated to form organic soils. Gleyed soils are in slight depressions and nearly level areas.

In areas that have greater slopes, runoff is more rapid than on the less sloping areas. Consequently, the surface and subsoil layers of soils on sloping areas have a predominance of brown and reddish brown colors rather than being gray like those of the less well-drained soils. Likewise, there is less mottling in the subsoil. On steeper slopes the soil profile may be modified by soil creep. Also, shallow spots and rock outcrops occur on the very steep slopes where geologic erosion has kept ahead of soil formation.

### Effects of Climate

Climate is an important factor in the formation of soils. Soils formed under a dry climate have different characteristics than those formed under a humid climate. Generally, soils formed where there is little rainfall are less leached than those formed in the subhumid climate typical of much of the Puget Sound Area.

Climate also influences the kind of vegetation, and vegetation in turn influences the formation of soils. Grasses are generally predominant in areas where the average annual precipitation is less than 22

inches. Forests predominate in areas where there is more precipitation, but the effects of precipitation are also influenced by the ability of the soil to retain moisture.

Wind currents, elevation, relief, and exposure exert a marked influence on climate, often within short distances. Climate directly influences soil formation through its effect on the weathering of rocks, the removal and deposition of material by water, wind, and glaciers, and the moisture in the soil. Indirectly, it influences the soil to an even greater degree through its effect on vegetation.

### Living Organisms

All life on and in the soil has an important bearing on the formation of soil. The raw soil materials were first invaded by simple forms of life, such as bacteria and fungi, which grew and multiplied. When these organisms died, their bodies decayed and became incorporated with the soil material. Mosses and lichens next began to appear, followed by grasses, shrubs, and trees, all of which added organic matter to the soil. Soils became mixed when windthrows occurred in the forest. Likewise, rodents that dug and made burrows in the soil mixed the subsoil with the surface soil. The presence of organisms and rodents in a soil exert an important influence on aeration and on the availability of plant nutrients. The kind of organisms most active in a soil determine to some extent the degree of losses, gains, or translocations of nutrients and organic matter.

Soils formed under grasses and ferns with fibrous, deep-reaching roots have a very dark brown to black surface layer. In contrast, the surface layer of soils formed under coniferous and deciduous vegetation is brown to grayish-brown. The depth to which roots can penetrate is often determined by the characteristics of the subsoil. The remains of sedges, sphagnum moss, Labrador-tea, and the plants that tolerate wetness have added to the accumulation of peat in bog areas.

### Time

Many important characteristics of soils are determined by the length of time the soil-forming processes have been active. Young soils show little horizon differentiation. Most soil materials have weathered over a long period and have developed distinct horizons as the result of clay minerals moving downward in the profile and accumulating in the subsoil. In the earlier stages of development, the soil material is much alike throughout the profile, except for differences in color. Later, discrete amounts of clay accumulate and eventually a claypan may form.

## SOIL CLASSIFICATION AND INTERPRETATIONS

The soils may be classified into three gross regions: the rough mountainous uplands, the glaciated foothills and plains, and the alluvial bottom lands.

The rough mountainous uplands consist of rolling to steep well-drained and rocky soils of variable texture and depth to underlying bedrock. Water runoff is medium to rapid, and erosion hazard is moderate to severe. Actual erosion depends on the stability of the soils and density of vegetative cover.

The glacial terraces generally lie below 2,600 feet and are of two kinds: basal till of compact or cemented till and ablation till having a loose nature. Soils on the basal till are gently sloping to steep with variable texture and drainage generally less than 40 inches deep over dense till. Surface runoff and erosion are generally higher than from ablation till. Soils on ablation till are likewise gently sloping to steep, generally well to excessively drained, and usually of coarse texture with slight to medium erosion hazard.

Alluvial bottom lands have soils deposited by flowing water. Generally the soils are deep and coarse-textured in upper stream reaches where they are deposited out of swiftly flowing water and of finer textures in the middle and lower reaches where the water velocities are less. The finer material is a serious sediment source through stream and bank erosion.

Many observable and measurable soil features have been recorded in the field and laboratory, and soil mapping units established, for the purpose of classifying soils and identifying their locations.

### Distribution of Soils

The soil mapping unit, usually a soil series, type, and phase, is the most specific classification unit and is the basis for all the subsequent interpretative groupings of soils used in this Appendix. Mapping units are based on observable and measurable soil features and are used for classifying soils and recording their locations. Over 800 such soil units have been identified in the Puget Sound Area. The soil mapping unit furnishes information used for developing capa-

bility units, site groupings, and other groupings. Table 3 of Exhibit 1 provides more complete information. The location and extent of mapping units are best obtained from soil survey reports and maps which are usually available for reference in public libraries, offices of local soil and water conservation districts, and offices of the United States Department of Agriculture.

## Soil Interpretations

Each soil mapping unit is characterized by properties that may be evaluated to predict the suitability of land for different uses. These uses may include crops, forestry, water management, engineering, urban development, industrial development, wildlife food and cover, recreation, and other purposes, singly or in combination.

Attributes of soils for various purposes are noted briefly here. Because of the wide variety of purposes, these properties are discussed in greater detail in the interpretive Tables found in Exhibit 1.

Good soils for cropping purposes are characterized by fairly level topography, loamy textures, good tilth, and deep profiles with high water-holding capacities. These soils are generally in Capability Classes I, II, III, and IV. The areas of soil series by land capability class and subclass are summarized by river basins and watersheds in Exhibit 1, Table 9.

Soils are best suited for most urban purposes when they provide good drainage, are free from floodwater hazard, provide firm foundations for typical urban structures, and have low shrink-swell properties. Urban purposes include a great variety of needs. Free draining soils with low corrosivity are generally desirable. While poorly adapted soils can usually be made acceptable by engineering design, the cost of providing and maintaining the construction or special features needed under unfavorable conditions creates a tremendous economic burden in flood protection, drainage, transportation, and other public and private services. Capability Class IV and VI lands, consisting of soils lacking primary wetness limitations, generally have properties suitable for urban use. Classes I, II, and III alluvial soils typically have properties not highly suitable for urban use in this area.

Soils used for various engineering purposes become materials of construction and must accept treatment and compaction to provide specific properties, such as stability, imperviousness, high shear, and bearing strength.

Soils best serving streamflow protection should be stable, have good drainage characteristics, support dense vegetation, and be resistant to compaction or erosion under conditions of use and treatment. The nature of the soil, its disposition, and vegetative cover, should promote infiltration and deep percolation of precipitation and retard and reduce surface runoff. Each soil series is classified by hydrologic groups within the basins and watersheds (Exhibit 1, Tables 4 and 5). Soils in Hydrologic Groups A and B are most conducive to infiltration of water, while Groups C and D encourage runoff.

The acreages of soil series found in the Puget Sound Area are listed in Tables 4 and 5, and the properties of soil series are shown in Table 6 in Exhibit 1. These and other tables may be used to provide the reader with a basis for making interpretations and determining the suitability of soils for agricultural, urban and engineering uses.

## Capability Classes of Soils

Capability classification is a grouping of soils that shows, in a general way, the suitability of soils for most kinds of agriculture. It is a practical grouping based on limitations of the soils, the risk of erosion and sedimentation, and the way the soils respond to treatment.

Soils are classified into capability classes and subclasses in accordance with the degree and kind of their permanent limitations but without consideration of major, and generally expensive, landforming that would change the slope, depth, or other characteristics of the soil, and without consideration of possible but unlikely major reclamation projects.

In this system soils are grouped at two levels—the capability class, and the capability subclass. The eight capability classes in the broadest grouping are designated by Roman Numerals I through VIII, as shown in Figure 2-4, which broadly portrays their relative topographic association. Definitions of land capability classes follow:

**Class I**—Soils in Class I have few or no limitations or hazards. They may be used safely for cultivated crops, pasture, range, woodland, or wildlife. (Only small bodies of soils in the Puget Sound Area may be classed as I because of susceptibility to at least occasional damaging overflow, or other associated hazards).

**Class II**—Soils in Class II have few limitations or hazards. Simple conservation practices are needed when cultivated. They are suited to cultivated crops, pasture, range, woodland, or wildlife.

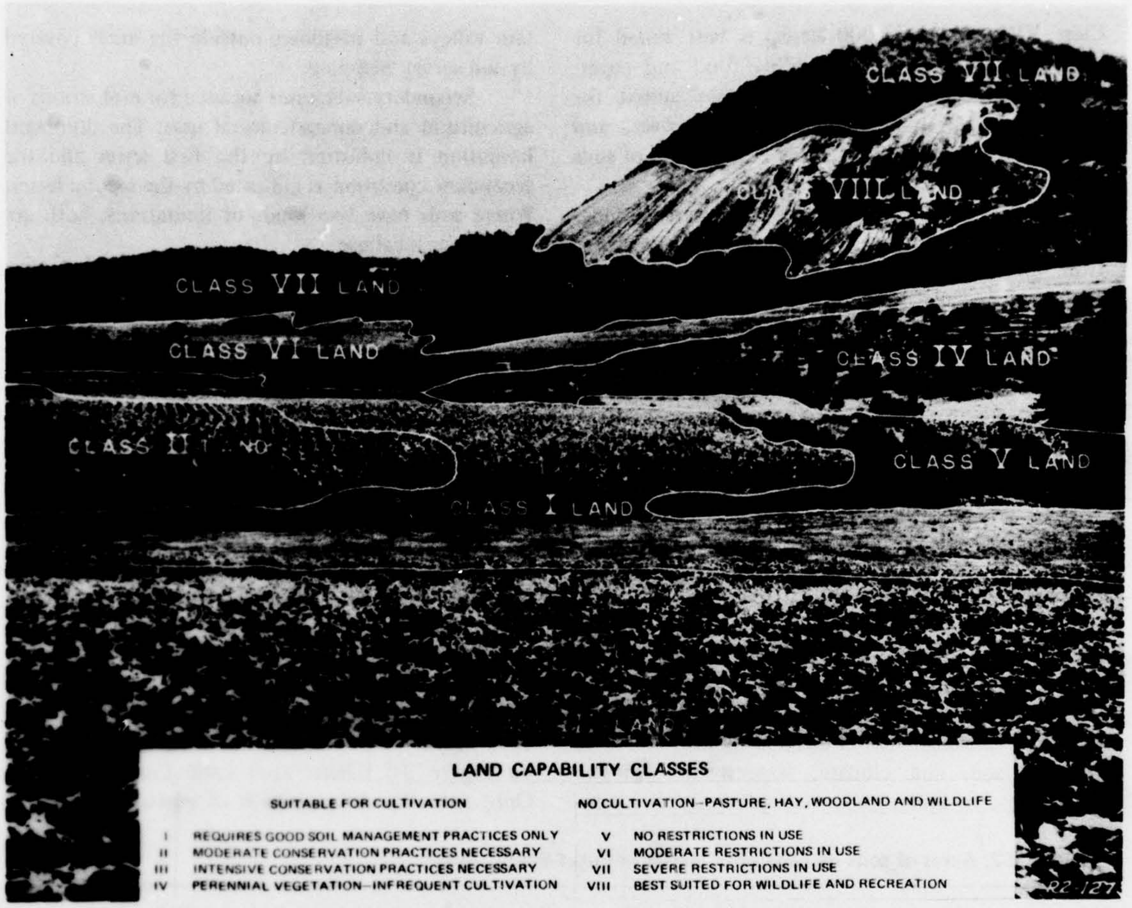



**FIGURE 2-4. The use and care of land should be suited to its capability.**

**Class III**–Soils in Class III have more limitations and hazards than those in Class II. They require more difficult or complex conservation practices when cultivated. They are suited to cultivated crops, pasture, range, woodland, or wildlife.

**Class IV**–Soils in Class IV have greater limitations and hazards than Class III. Still more difficult or complex measures are needed when cultivated. They are suited to cultivated crops, pasture, range, woodland, or wildlife.

**Class V**–Soils in Class V have little or no erosion hazard but have other limitations that prevent normal tillage for cultivated crops. They are suited to pasture, range, woodland, or wildlife.

**Class VI**–Soils in Class VI have severe limitations or hazards that make them generally unsuited for cultivation. They are suited largely to pasture, range, woodland, or wildlife.

**Class VII**–Soils in Class VII have very severe limitations or hazards that make them generally unsuited for cultivation. They are suited to grazing, woodland, or wildlife.

**Class VIII**–Soils and landforms in Class VIII have limitations and hazards that prevent their use for cultivated crops, pasture, range, or woodland. They may be used for recreation, wildlife, or water supply.

With the exception of lands lying within national forests and national parks, the soils of the Puget Sound Area have been classified into land capability classes to designate the intensity of land use management problems. Generally, Capability Classes II, III, and IV, comprising 2,087,000 acres, are suited for agricultural uses; and Capability Classes V, VI and VII, comprising 2,553,000 acres, are better suited for forestry, wildlife food and cover, recreation, and watershed protection. Land in Capability

Class VIII, about 52,000 acres, is best suited for watershed protection and wildlife food and cover. The unclassified 3,713,000 acres are suited for forests, recreation, wildlife food and cover, and watershed protection. (See Table 2-2 for acres of soils by capability classes in each basin).

Soil interpretations are based in part on judgment factors; thus, classifications vary somewhat from place to place and occasionally are changed. Certain steep soils, comprising about 100,000 acres in the Area, are well suited for production of timber. Classes VIIew 30, 31, 32; VIIes 29, 30, 31, 35; and VIIs 23 have recently been reclassified (1968) to VIew 30, 31, 32; VIes 29, 30, 31, 33, 35; and VIs 23 in recognition of lessened hazards under timber management. This Appendix has retained the Class VII classification, made prior to 1968, since tabulations were on this basis.

## Capability Subclasses

As shown, the Roman Numeral indicates the intensity of problems. The subclasses indicate the kinds of limitations within the classes. The subclasses are shown by letters e, w, s, and c following the numerals to indicate limiting conditions of erosions, wetness, soil, and climate, respectively. Climatic limitations are minor and occur primarily in mountain valleys and meadows outside the areas covered by soil survey mapping.

Secondary subclasses are used for evaluations of agricultural and nonagricultural uses. The dominant limitation is indicated by the first letter and the secondary condition is indicated by the second letter. Where soils have two kinds of limitations, both are needed for local use.

There are 3,367,704 acres outside the national forests and national parks considered to have a moderate to very severe potential erosion and sediment-producing hazard. Lands in the national forests unclassified by soil surveys but believed to be in Capability Classes VI and VII have a severe to very severe erosion hazard when vegetative cover is disturbed. Land in Class VIII is generally not highly susceptible to erosion because of its rocky nature.

Wetness resulting from overbank flow of streams, ponding due to restricted drainageways, and accumulations of unwanted water in terrace or upland soils, cause limitations in land use on 2,037,000 acres (subclasses ew, we, ws, and sw on Table 2-3), covered by the soil survey.

Water management and erosion problems have been broadly grouped and classified to locate them on Figure 2-5, Generalized Land Conditions map. Only naturally dense growth of vegetation prevents

**TABLE 2-2. Acres of soils by capability classes in Puget Sound Area[1]**

| River Basin | Capability Classes | | | | | | | Not Classified[2] | Total[3] |
|---|---|---|---|---|---|---|---|---|---|
| | II | III | IV | V | VI | VII | VIII | | |
| Nooksack-Sumas | 42,831 | 116,852 | 98,546 | 240 | 28,972 | 225,952 | 3,093 | 275,752 | 792,238 |
| Skagit-Samish | 83,012 | 45,659 | 73,135 | 39 | 68,121 | 244,700 | 8,515 | 1,389,373 | 1,912,554 |
| Stillaguamish | 20,327 | 22,819 | 30,412 | 0 | 51,230 | 130,878 | 2,659 | 175,302 | 433,627 |
| Whidbey-Camano | 5,447 | 6,229 | 62,028 | 0 | 51,439 | 3,416 | 4,376 | 0 | 132,935 |
| Snohomish | 51,627 | 46,516 | 153,679 | 911 | 126,313 | 276,653 | 5,071 | 533,820 | 1,194,590 |
| Cedar | 13,815 | 14,096 | 146,386 | 664 | 53,589 | 40,414 | 1,237 | 93,734 | 363,935 |
| Green | 25,208 | 8,676 | 93,186 | 230 | 21,585 | 58,600 | 1,214 | 131,534 | 340,233 |
| Puyallup | 26,923 | 39,834 | 128,391 | 219 | 89,004 | 162,976 | 6,862 | 304,841 | 759,050 |
| Nisqually | 6,411 | 51,354 | 83,790 | 0 | 66,580 | 154,174 | 1,236 | 91,241 | 454,786 |
| Deschutes | 7,363 | 18,160 | 54,525 | 0 | 44,419 | 42,096 | 1,015 | 13,230 | 180,808 |
| West Sound | 20,150 | 105,226 | 282,517 | 138 | 364,228 | 131,276 | 11,980 | 365,872 | 1,281,387 |
| Elwha-Dungeness | 8,424 | 30,851 | 20,940 | 0 | 12,684 | 32,474 | 2,944 | 338,296 | 446,613 |
| San Juan | 1,284 | 25,667 | 14,891 | 0 | 46,225 | 22,156 | 1,350 | 0 | 111,573 |
| Total | 312,822 | 531,939 | 1,242,426 | 2,441 | 1,024,389 | 1,525,765 | 51,552 | 3,712,995 | 8,404,329 |

[1] Unadjusted measurements, 1966, for Puget Sound Area Study, based on National Cooperative Soil Survey maps. Accuracy to three significant figures.

[2] Includes national forest, national park, and major urban areas.

[3] Does not include fresh water of 152,444 acres.

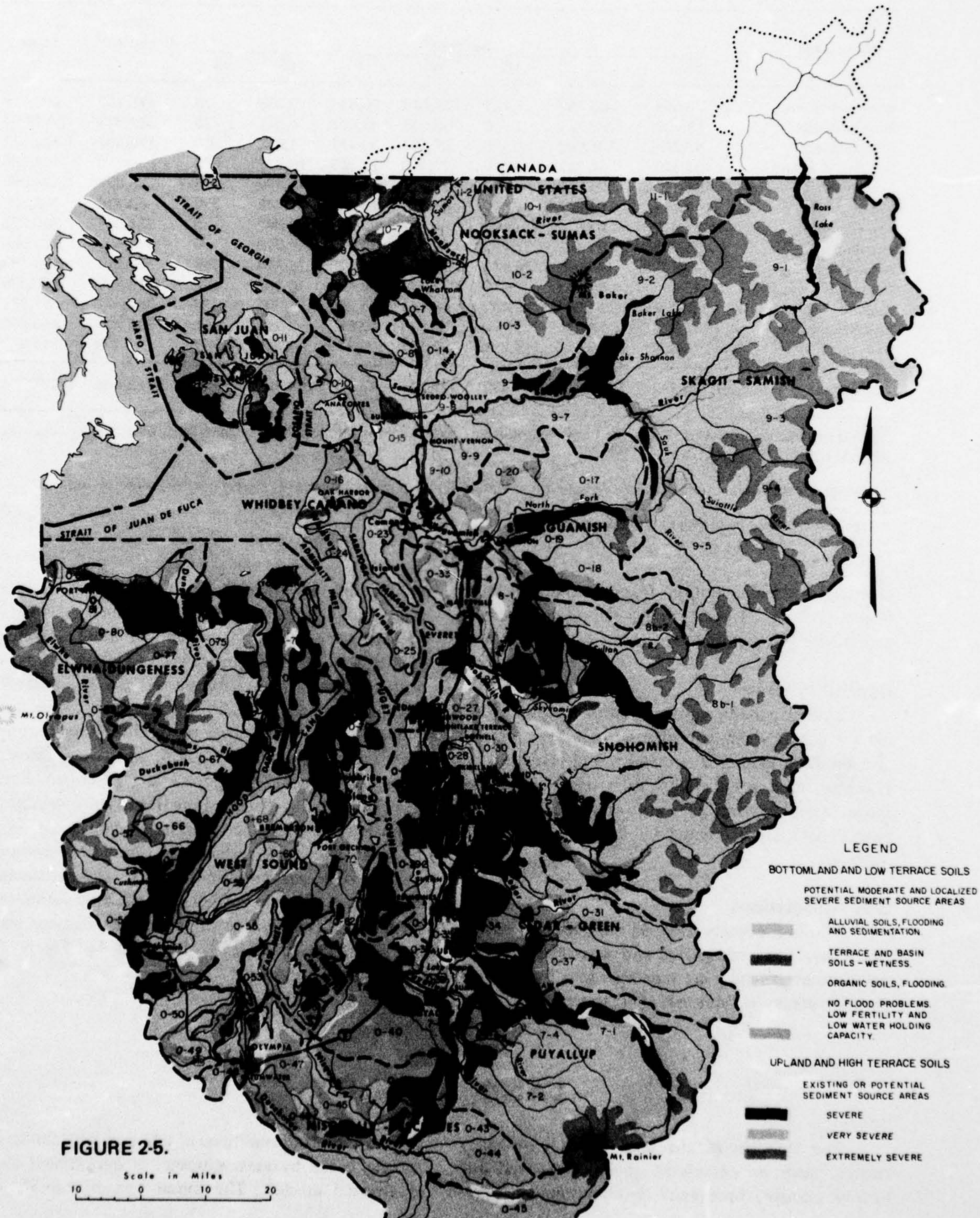



**FIGURE 2-5.**

**PUGET SOUND AND ADJACENT WATERS**
**STUDY AREA**

**2-13**
**Generalized Land Condition**

TABLE 2-3. Land conditions by capability subclasses, Puget Sound Area (in acres)[1]

| River Basin | Subclasses[2] | | | | | | | Not Classified[3] | Total |
|---|---|---|---|---|---|---|---|---|---|
| | ew | es | we | ws | s | se | sw | | |
| Nooksack-Sumas | 73,604 | 253,792 | 11,762 | 136,040 | 35,943 | 5,336 | 9 | 275,752 | 792,238 |
| Skagit-Samish | 59,439 | 267,771 | 0 | 150,006 | 38,870 | 4,375 | 2,720 | 1,389,373 | 1,912,554 |
| Stillaguamish | 43,244 | 135,540 | 0 | 35,414 | 39,411 | 4,516 | 200 | 175,302 | 433,627 |
| Whidbey-Camano | 64,120 | 15,782 | 0 | 20,350 | 21,385 | 10,312 | 986 | 0 | 132,935 |
| Snohomish | 164,822 | 301,683 | 0 | 91,911 | 57,209 | 43,229 | 1,916 | 533,820 | 1,194,590 |
| Cedar | 143,141 | 53,247 | 0 | 26,626 | 25,390 | 21,242 | 555 | 93,734 | 363,935 |
| Green | 71,873 | 67,430 | 1,961 | 34,717 | 23,871 | 8,847 | 0 | 131,534 | 340,233 |
| Puyallup | 80,223 | 183,743 | 17,415 | 68,077 | 75,933 | 28,818 | 0 | 304,841 | 759,050 |
| Nisqually | 40,413 | 162,669 | 35,143 | 33,483 | 64,636 | 26,354 | 847 | 91,241 | 454,786 |
| Deschutes | 18,507 | 60,314 | 0 | 21,736 | 46,797 | 16,707 | 3,517 | 13,230 | 180,808 |
| West Sound | 362,867 | 257,324 | 2,447 | 66,441 | 98,704 | 91,304 | 36,428 | 365,872 | 1,281,387 |
| Elwha-Dungeness | 44,820 | 31,819 | 0 | 20,818 | 10,860 | 0 | 0 | 338,296 | 446,613 |
| San Juan | 16,669 | 55,416 | 4,595 | 14,728 | 4,749 | 3,069 | 12,347 | 0 | 111,573 |
| Total | 1,183,742 | 1,846,530 | 73,323 | 720,347 | 543,758 | 264,109 | 59,525 | 3,712,995 | 8,404,329 |

[1] Undadusted measurements, 1966, for Puget Sound Area Study, based on National Cooperative Soil Survey maps. Accuracy to three significant figures.

[2] Letters for subclasses denote hazards or conditions that affect land use and treatmnet: e—erosion; w—water; s—soil.

[3] Unclassified land, including national forest and national park land.

erosion and sedimentation from becoming a very major problem. Under conditions of good cover, actual sediment yield is low.

## Capability Units

Land capability units consist of a group of soil units which have similar properties that cause them to give similar responses to treatment and management. Likewise, their productivity has a relatively narrow range. Areas of land capability units for the Puget Sound Area are tabulated by basins in Exhibit 1, Table 10.

## Soil Associations

Within the Study Area, 38 different soil associations have been recognized and described. The soil associations generally are separated into four physiographic areas to indicate: (1) those soils which dominantly have restrictive layers; (2) those soils lying on flood plains of main stem, primary tributary, or secondary tributary streams and those wet areas lacking well-defined drainageways; (3) those soil areas that dominantly are excessively drained; and (4) those soils which are shallow, stony, rocky, steep, and mountainous. Within each of the four broad groupings, there are ten, eight, seven, and twelve associations, respectively, recognized and described. Each soil association is described relative to its topography, drainage, topographic position, nature of soil materials with their permeability, drainage, elevation, climate zone, and precipitation. Also, the percentage distribution of each soil series is indicated within the association. Descriptions of the soil associations may be found in Exhibit 1, followed by Figure 3, Generalized Soils map.

# LAND STABILITY

The stability of the land depends on many factors, such as underlying geologic material and history, climate, topography, soil development, vegetative cover, and conditions of use. Loss of stability is usually noted by mass slippage, or detachment and accelerated erosion. The initial loss of stability is

PHOTO 2-1. Typical landscape at upper foothills area. (USFS)

compounded by transportation of sediment by gravity and water. This ultimately affects sediment loads and channel capacity of streams, siltation rates in reservoirs, harbors, and inundated areas, and water quality downstream. Wind is not a significant factor in soil movement in the Area. Runoff from watersheds is critical in causing erosion and sediment damage. The stability of land in the Puget Sound Area has an important bearing on present and future economy and various environment factors.

There are in excess of 7 million acres classed as having a moderate to severe erosion potential. Actual erosion taking place at the present time is nominal because of the generally excellent vegetative cover. The critical erosion area consists of the land disturbed by economic activity and the land damaged by natural disasters and other disturbances. The critical erosion area is estimated to include farm land annually left in an open condition during the winter season (estimated at 20,000 to 30,000 average acres); forest harvest (average 97,000 acres); forest roads (4,000 acres); and urban construction (7,000 acres); for a total of 138,000 acres each year disturbed by various forms of economic activity. The total critical erosion area at any point in time thus consists of the 138,000 acres annually disturbed by man in addition to lands damaged annually by wildfire, floods, landslides, channel erosion, and other similar activity; and lands recovering from all damaging activity of previous years.

## MASS SOIL MANTLE MOVEMENTS

Normal geologic erosion and natural earth movements have caused mass soil movements along parts of the Puget Sound coastline by wave action, and on the steeper mountainous slopes where the structurally weak mantle bedrock possesses deep-seated zones of weakness, or where shear zones or excessive moisture conditions have caused slippage within the soil mantle. The action of glaciers in higher areas causes considerable movement of soil and production of sediment.

The frequency and extent of mass soil movements can be related to certain site characteristics such as slope, geology, and soils. Mass soil movements appear to occur more readily in areas of steeper slopes, deep soils, and easily weathered bedrock.

Unconsolidated sediments of low internal strength, usually stratified, are especially vulnerable

**PHOTO 2-2. Steeply tilted formations contribute to unstable conditions. (USFS)**

when at or near saturation. An excessive amount of water involves an increase in water pore pressure and a decrease in the shearing strength of the soil. Also, a soil may owe its cohesion to a soluble binder. If a slope is saturated for the first time, and its binder removed by solution, the soil loses its cohesion. There are more than 494,000 acres of land in the Area that are subject to mass soil mantle movement when the soils become saturated. The soils may also be unstable when used for foundations or when used for highway construction and buildings.

Soils derived from incompetent rocks, such as shales, phyllite schists, slates, serpentines, and tuffs, are usually silt or clay in texture and are expecially subject to mass soil movements.

Unstable landscape characteristics are evident on the west slope of the Cascade Mountains where many old and recent age landslides have occurred.

**PHOTO 2-3. Headwall of debris slide on streambank channel of Camp Creek, Mt. Baker N. F. (USFS)**

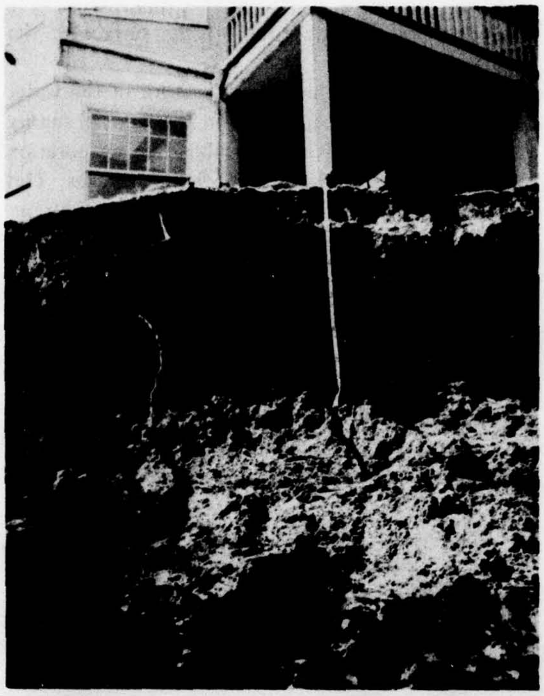


PHOTO 2-4. Slide of unstable soil mass below a home in King County. (SCS)

Landslides have occurred under various conditions, and with various materials. A large proportion of the slides occur as a result of loss of shearing strength in the mantle due to excessive amounts of ground water. Geologic conditions under which landslides often occur in the Area are as follows:

1. Unconsolidated glacial moraine overlying highly weathered colluvial material which is derived from Permian age slate and graywacke bedrock. These colluvial soils become highly plastic clays when saturated and exhibit low shearing strength.

2. Glacial moraine overlying a clay soil derived from weathered schist rock of Jurassic age. The clay soil is highly plastic when wet and extremely susceptible to failure and subsequent mass movement.

3. The Chuckanut formation of Tertiary age where steeply dipping sandstone and conglomerates have slid on interbedded shale. The shale becomes very plastic when wet and subsequently loses its shearing strength.

4. Sediments of the Chuckanut formation deposited on a pre-Tertiary serpentine basement. Clay has developed on the serpentine which creates a weak zone when saturated.

Changing the equilibrium of existing slopes by road construction within this area has caused mass soil movements in cases involving a variety of geologic formations and conditions. This is especially true in the steep mountainous area and adjacent foothills.

The normal geologic process of wearing away the landscape is occurring along the Puget Sound coastline. Wave action is undercutting the toe of the steeper coastline slopes, causing occasional landslides to occur. These slides occur within all types of glacial drift materials.

Numerous landslides have occurred within the Puget Sound lowlands. This area is thickly mantled with sediments of glacial and lacustrine origin. The fine-grained sediments have been extremely susceptible to mass soil movements when they become wet. Oftentimes, as in the case of road construction, landslides have occurred due to steepening of hillsides. The change in slope has been sufficient to trigger a slide when the underlying soil becomes wet. These slides have blocked travel on main highways for considerable periods of time before sediment was removed.

Slides and mantle slippage cause direct property damage and other damage when they occur in developed parts of the Area. These damages are not uncommon on waterfront and view areas in or near Seattle, Tacoma, and Olympia. During periods of excess precipitation in winter and late spring, houses sliding from their foundations is not an uncommon occurrence in these areas. The greater damage is usually indirect since slides happen most often in the

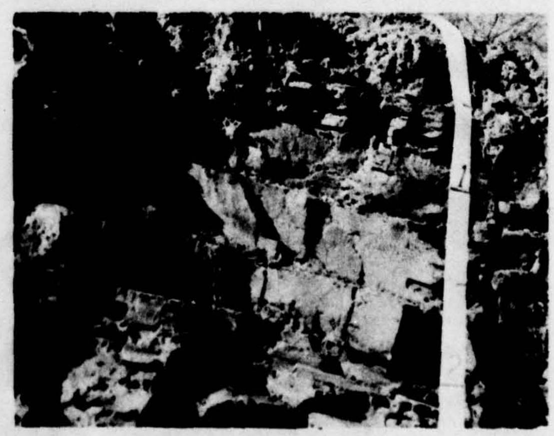


PHOTO 2-5. Platy structure and low shear strength are typical properties of silty substratum of lake-laid soils. (SCS)

mountainous areas and frequently block watercourses or occur where subsequent erosion and runoff can transport the loosened material through extensive downstream areas.

## THE WATER CYCLE

The water cycle is the endless process of circulation of water. Consideration of this circulation serves to focus attention on the nature of the water resource and the phases of management that are responsive to influence and modification.

Water from the ocean is evaporated into the atmosphere, eventually condenses, and falls to the earth's surface. Part of the precipitation soaks into the ground. Growing vegetation and evaporation account for some of the water passing through the soil; some reaches deeper zones and maintains the base flow of streams or replenishes ground water. The remaining precipitation runs off the surface of the land to the streams.

Circulation is the sailient feature of the water cycle. Moisture is precipitated on the land, primarily as rain or snow, and is then subject to evaporation from vegetation, soil, or free water surfaces. This collective loss of water is referred to as evapotranspiration, and is a consumptive use. Water not evaporated makes its way through soil and permeable rock to appear as stream or subterranean flow but will eventually be returned to the atmosphere either from fresh water bodies or the ocean.

The water cycle is rarely completed on any one watershed or land segment because all water added is not evaporated or transpired at that location and water yield from a watershed is a consequence of an incomplete cycle.

A zone of the water cycle of direct importance in forested watersheds is that occurring between the

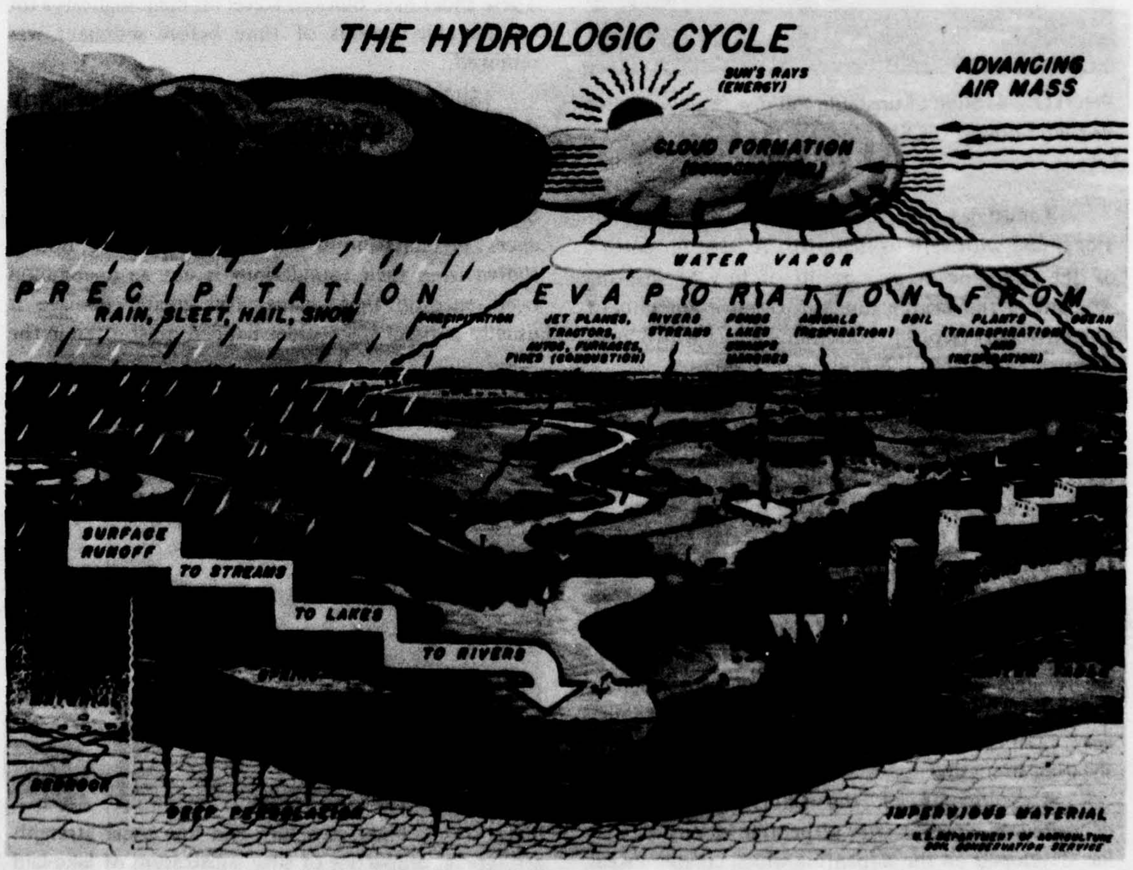



**FIGURE 2-6. Water is in continuous circulation.**

upper surface of the vegetative crowns to the deepest penetration of roots, and may be extended below the root zone by deep disturbances; e.g., excavation of roadways, or landings. Free water surfaces within a watershed are subject to natural water loss and disturbance and may be directly influenced through land use.

Processes occurring within the zone of influence are interception and evaporation of water from vegetative crowns, transpiration, infiltration, and evaporation from soil surfaces, percolation, filling and depleting of soil moisture storage, and surface runoff.

Soil erosion, although not part of the water cycle, is a primary consequence of it. Erosion may occur at an exposed soil surface or be deep-seated as in the case of massive slumps and landslides. Erosion may be natural or accelerated by watershed use.

The mobility of water provides a quality which clearly distinguishes it from most other natural resources. Vegetation, soil, rocks, and minerals, although subject to change, can be mapped and managed in place. However, the transient character of water in its cycle and in the watershed, causes diverse management problems. A large body of law has accumulated relative to its management and use; government at all levels has had an important role in its control and management; and economic, social, and political problems are quickly and closely involved. Upstream and downstream water problems–shortage, pollution, flood damage–inevitably interact; all this because "water will not stay where it is put."

The water cycle is a physical part of nature and is capable of modification by land-use practices in a watershed. Alterations in the water cycle can occur in the plant-soil-water relationships of the environment. The influences may extend in the form of modified water yields or water quality far beyond the site where land use changes of developments occur. Watershed management deals with these relationships of land use to streamflow and to soil and debris movement.

## EFFECTS OF SOILS AND COVER ON RUNOFF

A good vegetative land cover is a very effective means for maintaining soil water intake rates. Vegetation and topography vary widely in the Puget Sound Area and these factors have far-reaching effects on the runoff of water and transport of sediment. It is rare that overland flows of water damaging to the land occur in good cover, for the rooting systems of trees and grass make the soil porous and increase its permeability, while the accumulation of duff protects the land from freezing and otherwise improves the intake opportunity. Experience indicates this condition changes markedly when the land use is changed by developments or damaged by fire. Forest cover removal destroys the vegetative and duff protective cover and disturbs or destroys soil structure, thereby reducing water intake rates and increasing surface runoff. The increased runoff may be directly damaging, and in any event reduces the amount of water available to recharge the ground water supply, which, in turn, reduces the base flow of streams in summer and early fall.

Many experiments have been conducted to determine changes in outflow (or runoff) when hydrologic or cover conditions vary. The results of these experiments, and many years of observation, have made it possible to predict changes in flow characteristics from an area of land when the conditions of use are changed by development or natural accident.

The results of these observations have been developed for estimating the volume of flow, peak flow, and duration of flow from watershed areas.[1] The methodology is of considerable interest to the engineer or the watershed planner, since it can be applied to areas where streamflows have not been gaged, or to predict changes in flow caused by future changes in watershed use or condition. The runoff factors developed can be utilized to estimate volumes of runoff from rainfall.

### Hydrologic Soil Groups

In this method, soils are first grouped on the basis of intake rates where the rates are based on normal conditions and without the protective effects of vegetation. The hydrologic soil groups are usually defined as follows:

A. Lowest runoff potential; includes deep sands with very little silt and clay.

B. Mostly sandy soils less deep and less aggregated than A but the group as a whole has above-average infiltration after thorough wetting.

C. Comprised of shallow soils, and soils containing considerable clay and colloid, though less than

[1] Engineering Handbook, Section 4, Hydrology, Soil Conservation Service.

group D. The group has below-average infiltration after presaturation.

D. Highest runoff potential; includes mostly clays of high swelling percent but the group also includes some shallow soils with nearly impermeable subhorizons near the surface.

In practical application, the determination of hydrologic soil groups is made on a subwatershed basis. Soils of each subwatershed are classified as being one of the four major groups given above. The soil array is used to arrive at the average classification of the soils.

The general relationship between intake rate and hydrologic soil group is shown by Figure 2-7. This chart does not consider vegetative cover. The dashed lines indicate relative upper and lower limits caused by surface conditions and soil textures affecting intake rates. Soils of the Puget Sound Area have been classified as to hydrologic soil groups (see Exhibit 1, Tables 3, 4, and 5).

## Combined Effects of Soil, Cover, and Treatment

After the soils have been examined and classified into hydrologic groups, the condition of the soil structure, the kind of land use, and the land treatment are given attention. Types of land use and treatment are classified on a flood runoff producing basis. The greater the ability of a given land use or treatment to increase total rentention, the lower it is on a flood runoff production scale. The combination of soil cover and treatment thus evaluates the runoff character of the watershed, and is represented as a curve number in the solution of the runoff equation, Figure 2-8.

**Cropland** The sequence of crops on the watershed is evaluated on the basis of their effects on runoff. Usually in agricultural use crops are alternated (or rotated). Rotations are considered poor if a row crop or small grain is planted in the same field year after year. A good rotation will contain legumes or grass a large number of the years.

**Native Pasture or Range** This land is considered poor if heavily grazed; if no mulch has accumulated on the ground surface; or if plant cover in effect protects less than 50 percent of the surface area. Similarly, fair pasture or range protects 50 to 75 percent of the area and is not heavily grazed; good pasture or range covers more than 75 percent of the area with plant cover and is lightly grazed. It must be kept in mind the designations "fair," "good," and "poor" are hydrologic judgment factors and have

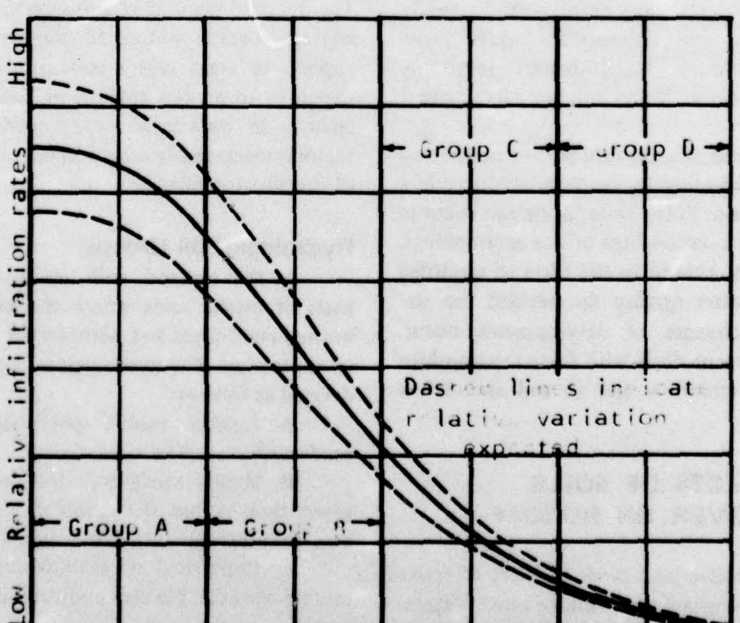
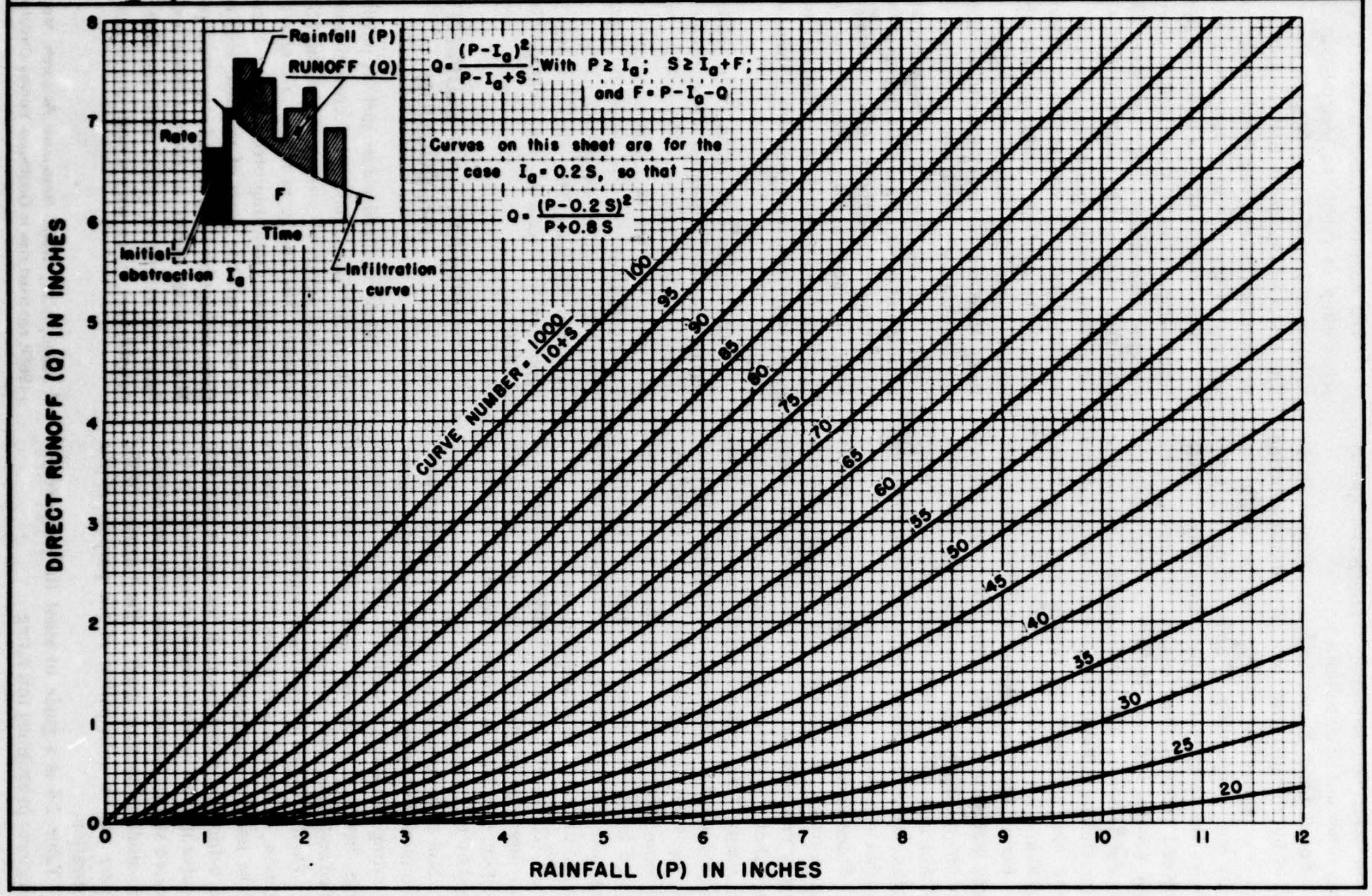



**FIGURE 2-7. Dimensionless diagram: relative infiltration potential by hydrologic soil groups.**

FIGURE 2-8. SOLUTION OF RUNOFF EQUATION $Q = \frac{(P-0.2S)^2}{P+0.8S}$

P = 0 to 12 inches
Q = 0 to 8 inches



only an incidental relationship to production, quality, or any other sort of classification.

**Forest Land**–Forest lands are classified on the basis of hydrologic factors, not on timber production capability. Important factors are the depth and quality and compactness of litter and humus. Litter includes the fermentation layer consisting of undecomposed (recognizable) remains of grasses, forbs, leaves, needles, bark, etc. It varies in depth somewhat with the season of the year, being thinnest in late winter. Humus includes the duff or raw humus as well as the mull in which the organic matter is incorporated into the mineral soil.

**Farm Woodlots**–Farm woodlots that are heavily grazed or regularly burned to destroy surface litter are rated poor; fair woodlots may have some litter but lack protection from excess grazing; good woodlots are protected so that litter and small shrubs and other vegetation cover the soil.

**Miscellaneous**–Areas in miscellaneous uses are rated primarily by judgment. In outlying areas this category may be so small as to be included with other uses. Lakes and impervious areas are a separate class with nearly 100 percent runoff. Impervious areas include pavements, rooftops, and heavily compacted soils. An urban development may exceed 60 percent impervious, while a highly developed city center will be rated nearly 100 percent impervious. Frequently streets and pavements are designed to rapidly concentrate and discharge accumulated water.

After the unit watershed has been classified as to average hydrologic soil group and infiltration condition, the vegetative cover is evaluated. Cover is judged by type and condition.

Soil cover, condition, and management of cover are combined with soil character and given a numerical rating between 1 and 100. These numerical ratings have been derived from experiments on studied and gaged watersheds.

These ratings are for soils in a normal moisture condition. If the soil is very wet, the curve numbers may be raised to compensate for moisture accumulated before the storm event; if the soil is very dry, the curve number is decreased to compensate for the increased storage capacity available in the soil mantle. These modifications are made in the judgment of the engineer and in anticipation of the purpose of the investigation.

Table 2-4 is a guide to assist the judgment of the engineer in assigning this rating.

The numerical rating is used to estimate the relationship of runoff to precipitation. Figure 2-8, Solution of Runoff Equation, gives this relationship. The effect of changes in land use and condition can be estimated by observing the changed curve numbers and using Figure 2-8 to evaluate the effect in runoff.

Since base flows of a watershed bear a reverse relationship to runoff, the effects of changes in land use and management on base flow also can be estimated. It should be noted that where peak flows are desired drainage geometry, slope, and size of the watershed must be considered in determining the form of the synthetic hydrograph that represents the runoff. Figure 2-9, Effects of Land Use and Treatment Measures on Direct Runoff, is an example of the changed hydrograph due to changes in land use. Methods of constructing such hydrographs, or of routing and combining unit hydrographs for locations downstream, are given in standard references. Sediment movement and erosion are related to velocity. The high form of watershed hydrograph will result in velocities that increase sediment delivery very significantly.

The generalized effect of urbanization with certain necessary assumptions have been reported by James,[1] using empirical coefficents to route a series of synthetic flows as a digital computer program. These data have been transposed to the graph, Figure 2-10, which reduces the basic data to a one square mile drainage basin. The relation shown is probably applicable in a general way to Puget Sound Area conditions.

## EROSION AND SEDIMENT PRODUCTION

While localized places such as portions of the San Juan Islands, have wind erosion problems, the dominant agency of erosion in the Puget Sound Area is water. The energy in falling rain serves to detach soil particles from unprotected land. Accumulations of water saturate areas of unstable soils and render them susceptible to slides and other mass movements. Moving water serves to further erode exposed surfaces, as well as to collect and transport sediments downstream, often with serious consequences. These

[1] James, L.D., Water Resources Research, Vol. 1, No. 2 (1965), reported also in Geological Survey Circular 554.

**TABLE 2-4. Runoff curve numbers for hydrologic soil groups (average moisture conditions)**

| Land Use or Cover | Treatment or Practice | Hydrologic Condition | Hydrologic Soil Group A | B | C | D |
|---|---|---|---|---|---|---|
| Fallow | Straight row | -- | 77 | 86 | 91 | 94 |
| Row crops | Straight row | Poor | 72 | 81 | 88 | 91 |
| | Straight row | Good | 67 | 78 | 85 | 89 |
| | Contoured | Poor | 70 | 79 | 84 | 88 |
| | Contoured | Good | 65 | 75 | 82 | 86 |
| | Contoured and terraced | Poor | 66 | 74 | 80 | 82 |
| | Contoured and terraced | Good | 62 | 71 | 78 | 81 |
| Small grains | Straight row | Poor | 65 | 76 | 84 | 88 |
| | Straight row | Good | 63 | 75 | 83 | 87 |
| | Contoured | Poor | 63 | 74 | 82 | 85 |
| | Contoured | Good | 61 | 73 | 81 | 84 |
| | Contoured and terraced | Poor | 61 | 72 | 79 | 82 |
| | Contoured and terraced | Good | 59 | 70 | 78 | 81 |
| Close-seeded legumes[1] or rotation meadow | Straight row | Poor | 66 | 77 | 85 | 89 |
| | Straight row | Good | 58 | 72 | 81 | 85 |
| | Contoured | Poor | 64 | 75 | 83 | 85 |
| | Contoured | Good | 55 | 69 | 78 | 83 |
| | Contoured and terraced | Poor | 63 | 73 | 80 | 83 |
| | Contoured and terraced (3-8%) | Good | 51 | 67 | 76 | 80 |
| Pasture or Range | | Poor | 68 | 79 | 86 | 89 |
| | | Fair | 49 | 69 | 79 | 84 |
| | | Good | 39 | 61 | 74 | 80 |
| | Contoured | Poor | 47 | 67 | 81 | 88 |
| | Contoured | Fair | 25 | 59 | 75 | 83 |
| | Contoured (3-8%) | Good | 6 | 35 | 70 | 79 |
| Meadow (permanent) | | Good | 30 | 58 | 71 | 78 |
| Woods (farm woodlots) | | Poor | 45 | 66 | 77 | 83 |
| | | Fair | 36 | 60 | 73 | 79 |
| | | Good | 25 | 55 | 70 | 77 |
| Forests | | Poorest | 56 | 75 | 86 | 91 |
| | | Poor | 46 | 68 | 78 | 84 |
| | | Medium | 36 | 60 | 70 | 76 |
| | | Good | 26 | 52 | 62 | 69 |
| | | Best | 15 | 44 | 54 | 61 |
| Farmsteads | | -- | 59 | 74 | 82 | 86 |
| Roads (dirt)[2] | | -- | 72 | 82 | 87 | 89 |
| (hard surface)[2] | | -- | 74 | 84 | 90 | 92 |

[1] Close-drilled or broadcast.

[2] Including rights-of-way.

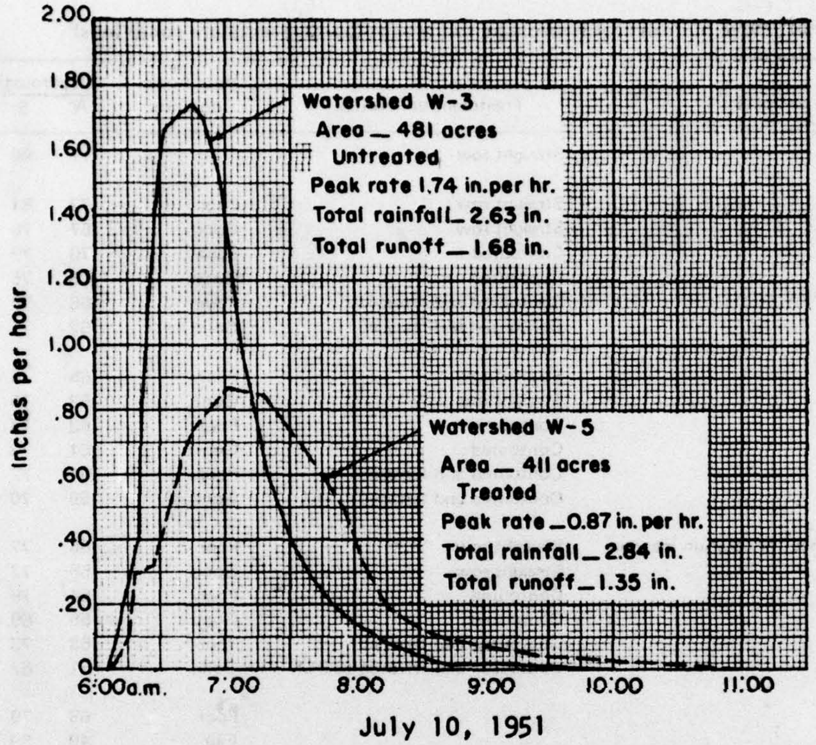



**FIGURE 2-9. Effects of land use and treatment measures on direct runoff.**

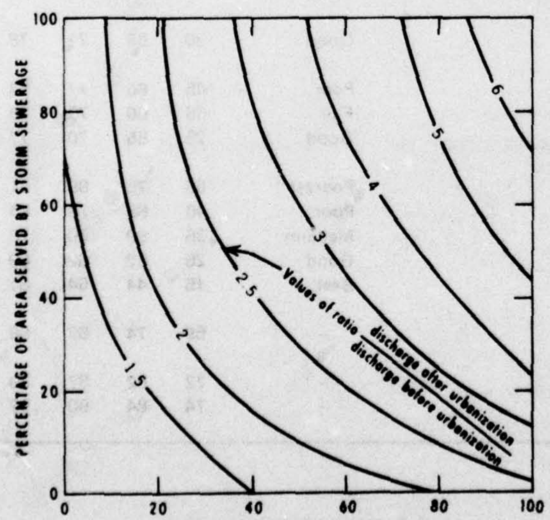



**FIGURE 2-10.–Effect of urbanization on mean annual flood for a 1-square mile drainage area. (James)**

effects are apt to be cumulative since eroded land causes changes in the action and movement of water that, in turn, increase the effect of water on the land. Some of the elements of this chain-like process are discussed here.

Based upon soil surveys made outside the national forests and national parks, an estimated 3,368,000 acres of land are susceptible to moderate to very severe erosion hazards when the vegetative cover is removed or destroyed. The national park and national forest lands (about 3,490,000 acres) have low intensity soil surveys and have not been fully evaluated for erosion hazards. However, because of their physiographic position, geology, topography, and shallow soils overlying bedrock, their erosion potential is estimated to be severe to very severe. The severity of the potential is assumed to parallel the potential sediment source (Figure 2-5, Generalized Land Conditions map). The relatively moderate rate of erosion experienced at the present time on these steep lands is contingent on maintaining a good, dense vegetative cover under adequate management.

The land characteristics, however, are of prime importance in planning future use and treatment for any purpose.

## The Soil Reservoir

Water that enters the soil in depth does not flow over the surface, and the consequent reduction of surface flow generally reduces erosion and has a beneficial effect on stream regimen. A watershed in which a large part of the precipitation enters the soil is in good hydrologic condition, since the soil thus is a retarding storage reservoir with the effect of reducing peak flows and erosion and maintaining equitable base flows during dry periods. The properties of the land that influence this storage effect are the intake rate, the permeability, and the water-holding capacity.

Water intake rates are influenced by the condition and structure of the surface soil. This includes type and density of vegetation and previous history of cultivation. The soil structure is an arrangement of soil particles around an axis into various forms consisting of blocks, cubes, prisms, plates, or lacking in structure. Free water moves through the voids or pores. A medium-textured soil with stable granular or crumb surface structure may have equally as rapid water intake as a moderately coarse-textured soil. At the other extreme, a medium-textured soil with weak structural aggregates that allow the soil to puddle easily may have as low a water intake rate as a fine-textured soil. The surface soil structure and porosity may be protected and improved by vegetative cover of grasses, shrubs, or trees. Vegetative cover also provides protection against the impact of rainfall and compaction, thereby protecting the water intake rate.

Permeability of the soil horizons determines the internal rate of water movement, after water enters a soil. Permeability of water through a saturated column of soil is determined by the soil's texture, structure, porosity, and temperature. Water movement through soils with slow permeabilities in the subsoil may be at a lower rate than the surface intake rate. This causes saturation of the soil column above the restricting layer. Free water then accumulates on the surface and the runoff rate depends upon slope of the land and density of vegetative cover.

Water-holding capacity is the supply of moisture retained by a soil after the removal of gravitational water. The water-holding capacity of a soil is determined by its texture, structure, porosity, and depth. The coarse-textured soils have the lowest capacity for storing water and fine-textured soils in the highest capacity. However, fine-textured soils hold water securely in capillary pores, thereby creating a low recharge capacity. The medium-textured soils create optimum soil texture and structure conditions for the recharge of water storage capacity.

Generally, coarse-textured soils (coarse sands, sands, gravelly coarse sandy loam, and loamy sands) are capable of storing 0.04 to 0.12 of an inch of water per inch of soil; moderately coarse-textured (coarse sandy loams, gravelly loams, sandy loams, and gravelly silt loams) store 0.12 to 0.14 of an inch of water per inch of soil; and medium-textured soils (silt loams and loams), moderately fine-textured soils (silty clay loams, clay loams, sandy clay loams), and fine-textured soils (clays, silty clays, and sandy clays) are capable of storing 0.14 to 0.20 of an inch of water per inch of soil. Organic soils store 0.17 to 0.20 of an inch of water per inch of soil. (For additional information, see Exhibit 1, Table 6).

Excess water runs off when the soil water storage capacity is reached, or when precipitation exceeds the water intake or permeability rate of the soil. On soils with slow permeabilities, the direct runoff may approach 70 percent. The source of floodwater runoff is generally those soils having slow permeabilities or having slow intake rates or low recharge rates. Vegetative cover has a large effect on intake rates and permeabilities.

## Erosion Progression

Changes in watershed characteristics caused by housing, industrial development, or vegetative deterioration, may cause sharp and accumulative increases in the damages caused by floodwater and sediment. Small watersheds respond more rapidly than large watersheds to changes in land use but the effects of sediment production from small basins have secondary effects on larger streams out of proportion to the area of the tributary watersheds.

Rational consideration of a given watershed should include the drainage geometry and mantle stability as well as the vegetative cover. Each natural watershed has developed in an environment where running water and mass gravity movements, acting through long periods of time, have produced a unique equilibrium. The stability of the equilibrium and the likelihood of its being upset are hazards of any downstream development. Good watershed manage-

ment will undertake to guarantee that changes in use and treatment of watershed lands are combined to prevent excessive disturbance of stability or hydrologic character. The inherent stability of such lands varies greatly, and the needs of good management may range from nominal in character to complex requirements to improve the watershed and guarantee its maintenance before downstream developments are made.

The concept of the systems approach has been developed by Horton[1] and others. The watershed is considered as an open system tending to achieve a steady state of operation by importing and exporting matter and energy through the boundaries by the transformation of energy. In a watershed, the land surface within the basin perimeter is taken as the system boundary through which precipitation is imported, while mineral matter from within the system and excesses of precipitation are exported through the channels.

Erosion and transportation, averaged over the years, tend to achieve an equilibrium of steady flow wherein the potential energy of position (elevation) is equated with the kinetic energy of water, debris motion, and heat. Over geologic periods of time, a continual readjustment of components in the equation of the system is necessary as elevation lowers and available energy diminishes.[2]

If a process brings new conditions into being, the new steady state is preceded by a transient erosion process where the system of channels develops rapidly in pattern, intensity, and depth as a revised drainage network is established. In the Puget Sound Area, where many of the land forms are relatively new, the processes of erosion are typically more responsive to treatment and use than in many parts of the nation, and the condition of the land surface is closely related to the condition of the outflowing streams. In the so-called steady state, environment is adjusted to transmit only the quantity of water and detritus characteristic of the watershed and climate. Should controlling factors be changed, the steady state will be upset and replaced by transient conditions characterized by rapid changes in surface geometry and sediment production.[1]

[1] Horton, R.E., Erosional Development of Streams and Drainage Basins, Hydrophysical Approach to Quantitative Morphology. Bull. Geologic Assoc. Amer., V. 56. 1945.

[2] Strahler, A.N., Hypsometric Analysis Erosional Topography, Bull. Geologic Assoc. America, V. 63. 1952.

In many watersheds of the Puget Sound Area, large amounts of erodible sediments are present and continuance of the steady state depends on continuance of effective vegetative cover.

It is useful to note that relationships between form elements and causitive factors can be expressed by rational equations. Because of the geometric character of erosion, certain scalar properties are useful for purposes of comparison. One of these is drainage density (D) which describes the horizontal scale or spacing of equivalent drainage watercourses. The drainage density may be related to a series of independent variables. It may be noted that the response of runoff to precipitation is greatly affected by the time required for the first stage overland flow to reach developed watercourses; and that any material increase in the density of such watercourses in steep land decreases the length of overland flow, shortens the time of concentration, increases velocity, and greatly increases sediment exportation.

$D = (Qr, K, x)$, where

- Qr is the volume rate of flow per unit area;
- K is the mass rate of erosion per unit of force per unit of area;
- H is relief in differentials of elevation in feet;
- x represents several terms, such as density of fluid, viscosity of fluid, and acceleration due to gravity; and D is in terms of total channel length per unit area.

An estimated average value of 0.97 for "D" in the above relation was used to represent channels draining not less than one square mile for the special purposes of the first National assessment (1968) of streambank erosion. This value would be considerably higher if lesser channels were considered and, of course, would vary greatly for specific watersheds within the Area.

Of these quantities, the term QrK (sometimes known as the Horton number) expresses the relative intensity of the erosion process. Conditions of the steady state are such that for a given Horton number the basin geometry has adjusted to transmit the given quantity of water and debris produced under the climatic regimen.

However, if the steady state is upset, as by denuding a forested area, or by replacing vegetation in a critical area by urban development, the Horton number will sharply increase, either through increase

in intensity of runoff, susceptibility to erosion, or simultaneously to both. In compensation, the basin geometry is altered by gully development to increase the drainage density, increase channel and ground water gradients, and decrease local relief by depletion. A period of transformation from one steady state to a new but degraded steady state is the result of depleting forces exceeding a critical point. The transient state, while a brief geologic transformation, may cause large damages to property and developments and various environmental values downstream.

The new steady state, when finally achieved, will be only at a much higher level of erosion intensity. The badlands, from which sediment is produced at high rates, will have replaced long, comparatively smooth slopes of land. Stream gradients through aggradation will have steepened, and secondary effects beyond the unit watershed will be produced. The secondary effects may include swamping of downstream lands, increased streambank erosion and flooding, and deterioration of reservoir sites and harbors.

In the Puget Sound Area, there is close proximity between the highly developed lowlands and the steeper watershed areas of the foothills and mountains, so that the secondary effects are more prominent and the rate of response greater than would be the case if the areas were separated by greater distances and more gentle topography. Much of the existing management is presently oriented toward control of erosion. Continuation and improvement of these practices on critical lands is essential.

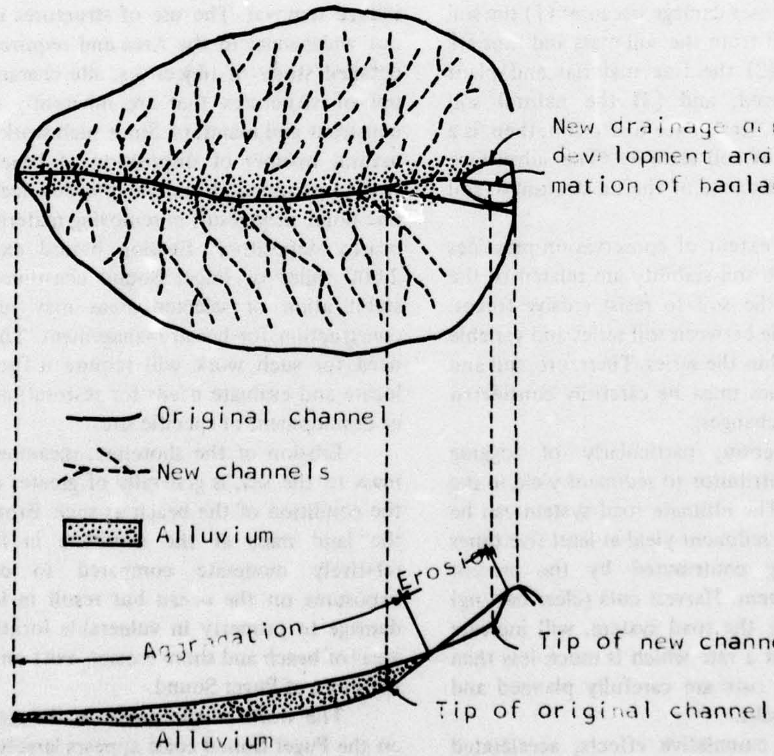



**FIGURE 2-11. Drainage-density transformation, showing development of eroding badlands and deterioration of hydorlogic runoff quality.[1]**

[1] After Strahler, A. N., Dynamic Basis of Geomorphology, Bulletin Geologic Soiety America, V. 63, 1952.

## Soil Detachment and Movement

The process of soil erosion involves soil detachment and soil transportation. Soil characteristics that describe the ease with which soil particles may be detached and transported are soil detachability and soil transportability. The natural chemicals which add to the ability of a soil to form aggregates are generally derivatives of the humates and humic acids and are by-products of vegetative growth and decay. These chemicals and water lend stability to soil when in proper balance. However, stability is likely to break down when either a dry or extremely wet condition prevails, or when the organic content of the soil is reduced. In general, soil detachability increases as the size of the soil particles increases, and soil transportability increases with a decrease in particle size; i.e., clay particles are more difficult to detach than sand but clay is more easily transported.

Detachment causes damage because: (1) the soil particles are removed from the soil mass and thus are easily transported; (2) the fine material and plant nutrients are removed; and (3) the natural soil structure is disturbed. Resistance to erosion, then, is a surface component of soil stability. The subsurface component is the resistance of the substratum to soil movement.

The type and extent of conservation practices needed to accomplish soil stability are related to the inherent ability of the soil to resist erosive forces. This ability is variable between soil series and variable as to soil phases within the series. Therefore, soil and geologic characteristics must be carefully considered in planning land use changes.

Road construction, particularly of logging roads, is a major contributor to sediment yield in the Puget Sound Area. The ultimate road system can be expected to increase sediment yield at least five times over what is being contributed by the present incomplete road system. Harvest cuts (clear cutting) of timber, excluding the road system, will increase sediment yield but at a rate which is much less than roads, provided the cuts are carefully planned and executed in small blocks.

Due to their cumulative effects, accelerated road construction and timber harvesting may increase the potential for mass soil movement and the rate of surface erosion unless the area is carefully managed and rehabilitated following disturbance.

**Coastal Shore and Beach Erosion**—Beaches are the relatively unstable margin of transition where the land mass and tidal water meet. Accretion and erosion of beaches and adjoining shoreline areas are the result of natural forces acting on the exposed land mass with particular vigor in this transition zone. These forces include gravity, tidal exchange, tidal currents, and wind waves. Such forces combine in complex patterns to affect onshore, offshore, and alongshore movement of beach sediments, combined with the disposition of available supplies of new sediment derived from erosion processes acting on the land mass. The resultant of these forces may change with the season or with storm events; and the long-term average consequences determine whether the beach margin increases by accretion or diminishes through lack of material being deposited to replace that lost.

Management of localized beach areas by the use of structural measures can, in some cases, stabilize the accumulation of sediment, encourage accretion, or induce removal. The use of structures in this way is not widespread in the Area and requires careful and detailed study of objectives, site characteristics, and use of structures that are inherently expensive to construct and maintain. Since such work modifies the natural manner of disposition of beach sediments, structures aimed at increasing beach accumulation at one point may result in removing material from some nearby depository. Erosion hazard exists on over 2,000 miles of Puget Sound coastline, and future stabilization of selected areas may justify greater construction for beach management. The extent and need for such work will require a future study to locate and evaluate needs for restoration, protection, or development of specific sites.

Erosion of the shoreline, meaning loss of land mass to the sea, is generally of greater concern than the condition of the beach as such. Erosive forces on the land mass at the shoreline in the Area are relatively moderate compared to corresponding exposures on the ocean but result in land loss and damage to property in vulnerable locations. Critical areas of beach and shore erosion exist on 187 miles of the shore of Puget Sound.

The work of the waves in the erosion process on the Puget Sound coast appears largely mechanical, rather than dependent mainly on the solvent power of the water or upon weathering action. Waves appear to cause a gradual undermining of the sea cliff, so that material is finally dislodged by gravity, falls, and is ground up by wave action. In many places the sea edge is terminated by a cliff-like face where erosion is

advancing inland. At the foot of the cliff, talus is removed and a wave-cut terrace remains. The sea cliff itself is often compact sedimentary material containing strata of clay, compact sands, and sandstone. Under these circumstances, the slope of the cliff is determined mainly by the relative resistance of the material to wave action, compared to weathering. The cliff face is thus often quite steep except where the material is composed mainly of sand. Sand cliffs tend to assume the angle of repose.

A considerable portion of the wave-cut terrace or shore platform along the eastern shore of the Sound north of Tacoma is occupied by railroad rights-of-way. Tracks are somewhat elevated on this foundation and protected against wave action by heavy rocks placed along the embankment. Along much of the sea cliff, erosion and loss of stability is increased by seepage from natural causes and concentrations of seepage induced by developments along the summit of the cliff. Slumping and erosion cause loss of property and occasional interruptions in railway service.

The beach along these cliffs is relatively narrow but widens in the vicinity of estuarine zones of major rivers and along protected coves and bays. In the Skagit and Nooksack Basins, some such areas have been reclaimed by the use of seawall dikes and are used for farming. These dikes are subject to wave action and require considerable maintenance. In other areas, sand spits and bars have formed, some of which are useful for recreation sites, boat moorages, or Coast Guard installations.

**PHOTO 2-6. Railway workmen clearing one of two tracks after a landslide five miles north of Edmonds in Februray 1969 covered both of the railway's lines. Officials were unable to estimate the cost of damage to the tracks.—Seattle Times staff photo by Bruce McKim.**

While much of the shoreline is subject to erosion, the following summary by river basins indicates an estimate of the areas affected to a considerable extent:

**Nooksack-Sumas Basins**—Those areas subject to beach erosion include shores now protected by sea dikes, as well as unprotected areas which include low-lying lands on Birch Bay, Blaine, Bellingham Bay, and Lummi Island. On Lummi Island the problem is aggravated by seepage from built-up areas adjacent to the beach cliffs. About five miles of beach and cliff area are involved.

**Skagit-Samish Basins**—There are about 15 to 20 miles of dikes, revetments, and railway roadbeds protected by revetments, which are subject to wave action damage. Maintenance is high on many of these improvements but largely neglected on cliff areas unless needed to protect specific improvements.

**Stillaguamish Basin**—The shore area north of the Stillaguamish River is protected by dikes which are subject to damage by wave action. The reach involved is about five miles.

**Snohomish Basin**—Wave action damage of moderate intensity occurs on the Tulalip Reservation to Everett and Mukilteo. This includes railroad beds which are protected by revetments and slide areas above the railroad. The distance is approximately 12 miles.

**Cedar Basin** (Mukilteo to Seattle)—About 25 miles of beach and shore area are subject to erosion and bank sloughing. In this area, the railroad parallels the beach, and the embankment is protected by revetments. The railroad protects much of the cliff area from wave action but slides occur at intervals.

**Green Basin** (Three Tree Point south)—An estimated six miles of beach and bluff erosion are caused principally by seepage and wave action. Vashon Island has about four miles of waterfront subject to beach erosion and sloughing of bluffs, often caused by excess seepage water.

**West Sound Basins**—Bainbridge Island and Kitsap Peninsula are subject to beach and cliff erosion for a distance of 25 miles. This includes erosion of beaches and sloughing of the bluffs caused by concentrations of seepage water. Hood Canal in Jefferson County has about ten miles of beach and cliff erosion. In Mason County, three to four miles of area are subject to beach and cliff erosion.

Included in the above totals is a sand spit at the head of Case Inlet in the southern part of the West Sound Basins. If erosion continues, a breach may occur in the spit that protects Vaughn Bay. In the northern part near Port Townsend, an existing breach in a sand spit that protects Kilisut Harbor is continually eroding.

**Whidbey-Camano Islands**—Whidbey Island has beach erosion in low areas which are protected by dikes and in unprotected low areas along the beach, as well as sloughing of sea cliffs. It is estimated that about 25 miles of beach area are affected. Camano Island has problems similar to those on Whidbey, affecting about six miles of beach and shore.

**Puyallup Basin**—The Pierce County peninsula is affected, primarily by sloughing of bluffs due to excess seepage water which includes septic tank effluent, on about three miles of beach. It is eroding at the rate of about one foot per year. The Sunnyside Beach near Steilacoom is about two miles long and has eroded about 25 feet in the last 20 years.

**Elwha-Dungeness Basins**—In Clallam County the low beach areas at the mouth of the Elwha-Dungeness are subject to erosion from wave action, and bluff areas are subject to slides from excessive seepage and wave action. Ten to fifteen miles of beach area are affected. Included is the erosion of Ediz Hook near Port Angeles which threatens to cut the narrow strip of land from the mainland.

**San Juan Islands**—About 15 miles of beach and shore area on the San Juan Islands are subject to damage from beach erosion and sloughing. This includes the beach erosion on Cattle Point, San Juan Island, and Shaw Island, as well as other islands. Some drifting dune sand is found near Cattle Point. On Point Roberts about five miles of waterfront are subject to beach erosion, and about one-third of that would be subject to sloughing.

**Study Needed**—A detailed study is needed for the purpose of establishing methods of erosion control on these beaches.

### Sediment Production

Existing soil surveys in the Area make it possible to classify 2,015,300 acres of land in Capability Classes VI, VII, and VIII with a severe or very severe erosion potential, and 1,352,400 acres in Classes II through IV with a moderate erosion potential. There are, in addition, 3,490,000 acres under Federal administration that are estimated from low-intensity surveys to have a severe or very severe erosion potential. An outstanding characteristic of the Area is that, while present erosion may be said to be nominal, the potential for erosion is very great and

serious erosion is prevented only by the generally excellent vegetative cover. The acreages enumerated above constitute critical erosion areas at any time vegetative cover is removed or seriously disturbed, and remain in this category until vegetative or other cover may again stabilize the soil mantle.

The expected economy of the Area will result in the removal of disturbance of vegetative cover on an average 138,000 acres annually as a result of forest harvest, road construction, and urban development. The critical erosion area at any point in time thus consists of newly disturbed lands; lands recovering from previous activity; lands and cover damaged by wildfire or other disaster such as landslide; and lands affected by shore and streambank erosion, flooding, and sedimentation.

Disturbance of the land is a part of human activity. Under the circumstances, the best management will hold the degree of disturbance to the minimum possible, apply protective measures to the disturbed area to prevent offsite effects, avoid undue concentrations of critical areas in any given watershed, and rapidly rehabilitate critical erosion areas to the best hydrologic condition possible.

In the Puget Sound Area, the most common agent of erosion is water. Material detached and moved from the soil body becomes sediment and is equal to the gross erosion. Sediments naturally move by relatively slow processes of alternating transportation and deposition until they reach well-defined channels where transportation by flowing water becomes a dominant feature.

Channel sediments vary widely in speed of movement downslope, depending on the transporting ability of the flowing water. Some sediment is stored in channel bars or as alluvium on flood plain. The amount of sediment passing a control point is the sediment yield at that point and is commonly expressed as tons per acre or, alternatively, as acre-feet per square mile of watershed area per year. Determining sediment yields by suspended load measurement is difficult and expensive, and few measurements of significant intensity or duration have been attempted in the Puget Sound Area.

An estimate prepared for the Columbia-North Pacific Type I River Basin Study (1969) indicates a generalized sediment yield of 1,600 acre-feet per year. Sources of this sediment were considered to be: from cropland, 9 percent; forest land, 63 percent; rangeland, 2 percent; and all other lands, 26 percent.

The proportion of sediment yield to gross erosion is the sediment delivery ratio. This ratio may vary from a few percent to nearly 100 percent, depending on circumstances. This ratio is of considerable technical significance because of esthetic and economic impacts upon the environment. In the absence of actual measurements, little can be said of quantitative conditions in this Area, except that the topographic forms would indicate a moderately high delivery ratio at points on intermediate stream reaches. The delivery ratio, typically, is higher in small watersheds and steep terrain, and has a tendency to sharply increase as erosion progresses and drainage densities increase.

Some sediment is produced by natural geologic forces of weathering and, in some parts of the Puget Sound Area, glacial activity generates large quantities of sediment in the streams draining the icefields. However, much of the sediment derived in this way moves slowly and requires long periods of time to reach stream channels.

A large amount of sediment is now produced as a result of housing, industrial, and other construction activities of man. Earthmoving machinery detaches and rearranges the soil and, in the process, removes vegetation and disturbs natural drainage passages. The supply of loosened material is augmented, and the action of overland flows is concentrated, to allow ready delivery of sediment to active streams.

Thus, the sources of sediment, once associated with the use of land for crops and forests, are being seriously augmented in some places by new and powerful sediment-producing activities.

Basic quantitative data on the relation of urbanization and other disturbances on sediment yield are lacking in the Area. Some such measurements in eastern United States have been summarized by Wolman,[1] who studied sediment yields from building activity and other activity in Maryland. Such urban yields were found, for very small areas, to exceed 20,000 to 40,000 times the amount eroded from farms and woodlands in an equivalent period of time. Figure 2-12 from Wolman relates the sediment yield and discharge for an urban and a rural or unurbanized area. This relation in a generalized way may apply to similar activities in the Puget Sound Area.

Sediments derived directly or indirectly from roadbuilding, urban developments, and similar activi-

[1] Wolman, M.G., Report to Maryland Water Pollution Control Commission: Annapolis, Md. (1964).

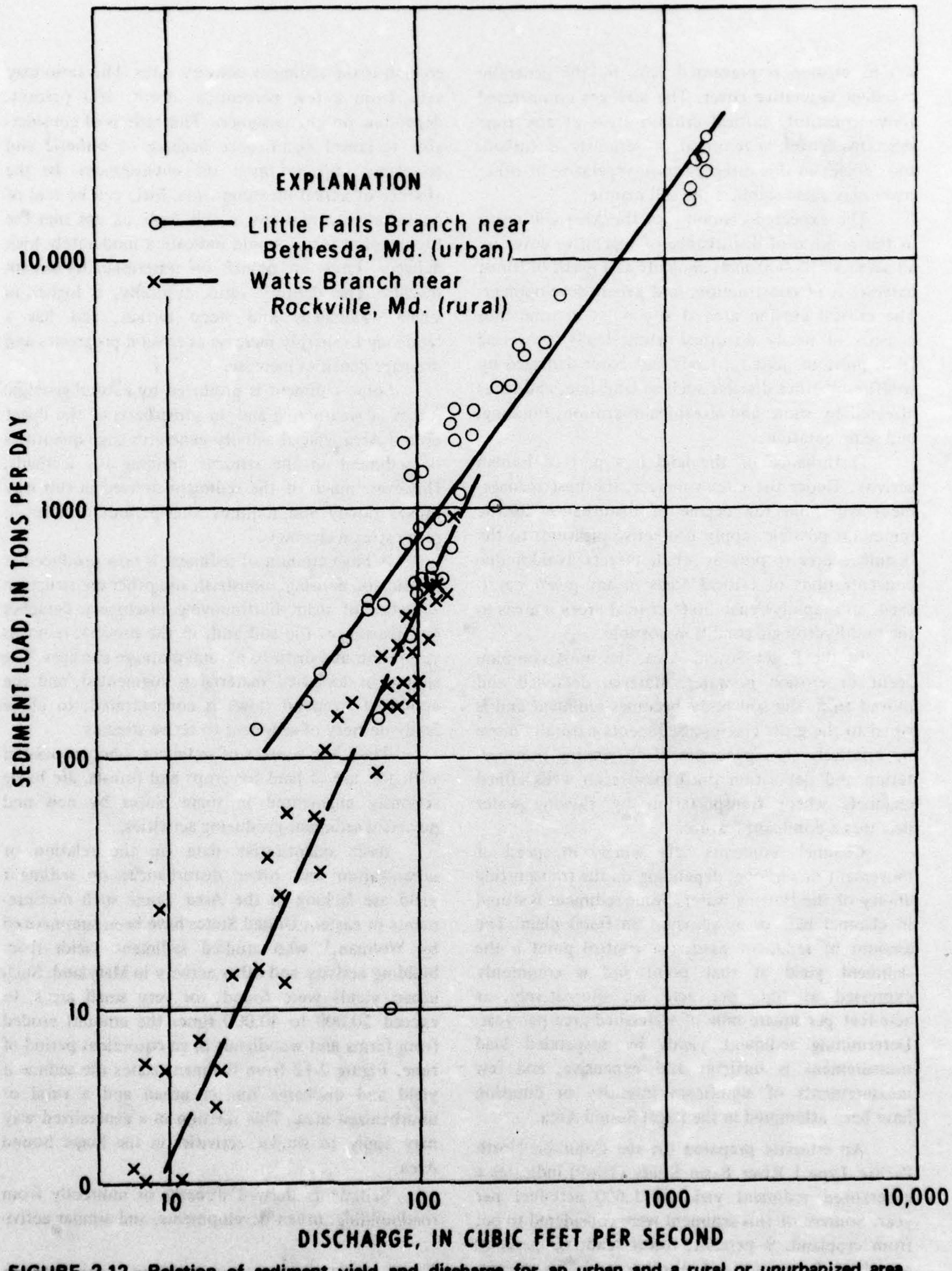



**FIGURE 2-12.–Relation of sediment yield and discharge for an urban and a rural or unurbanized area. (Wolman)**

**PHOTO 2-7. Fertile cropland is covered by massive fill for industrial site. Construction, unless carefully planned, produces much sediment. (SCS)**

ties, unless carefully managed, increase the gross supply of sediment and greatly increase the rate of export, causing severe local and general disturbances to the sediment load in streams.

Sheet erosion, which includes the detachment of soil from inadequately protected surfaces of land by the impact of rainfall, is widespread and is probably a major element in the gross erosion of the Puget Sound Area. Sheet erosion, unless promptly controlled, becomes more severe and, in advanced stages, tends to accelerate and become the more spectacular gully erosion.

Gully, or channel, erosion, which is the removal of soil by concentrations of flow, and erosion from slide areas, contribute significant amounts of sediment directly to stream channels in some places.

**PHOTO 2-8. Forest access road failure caused by slumping topography. (USFS)**

Stream channel erosion is of major consequence, not primarily because of the total volume of sediment thus produced, but mainly because sediment is produced at the watercourses with an extremely high delivery rate and consequently directly damages the stream systems. At the same time, loss of valuable land is occurring. Generally speaking, streambanks are eroded by saturation of bank materials and tractive forces acting on the banks. Often, the water reaches an erosive velocity when it is well below the top of the streambank. The water undercuts, or erodes away, the lower portion of the bank, leaving the upper portion unsupported. This upper portion then sloughs off into the water where the material is transported downstream. This is a repetitive process and is a typical form of bank-cutting.

Photo 2-9 shows a streambank which has been undermined by high flows of the stream. The sod has held the top portions despite undercutting; then the sod has given way, allowing the top portions of the bank to collapse and slide into the stream.

When forested streambanks are undercut, the trees and brush topple outward into the stream. The limbs, trunks, and roots of the trees float downstream and lodge on the nearest obstruction. As they lodge in the stream, they often cause an eddy or slowing of the water which deposits gravel on the branches and the trunk and holds them firmly in the channel. This, in turn, diverts the water from the channel and

PHOTO 2-9. Streambank, showing undermining of sod. (SCS)

against the banks on one or both sides of the trees. This diversion of the water against the banks causes further bankcutting and results in the accumulation of additional trees and brush in the main channel. In this manner, progressive bank erosion occurs for the duration of the flooding.

Concentrations of woody debris are common to many streams and as such are a potential damage threat, especially during periods of high runoff. Such debris can affect water quality, cause onsite and offsite physical damage, restrict recreational use, and hinder or stop fish migration. Experience has indicated that debris is one of the greatest contributors to aggravated stream damage in the Puget Sound Area.

Sometimes what is called "manufactured" debris results from man's activities. Manufactured debris adds to natural accumulations and may cause a disproportionate amount of damage. Debris is sometimes left in or adjacent to stream channels as a result of logging and roadbuilding. Debris on steep slopes can concentrate overland flow, leading to slumps or slides of woody debris and soil material into the stream channel below. Woody debris left in temporary and permanent road embankments, and under unstable waste material from road excavations, has also been known to trigger such slumps and subsequent debris problems. Since manufactured debris is directly related to road construction and timber harvest, the land use alternatives that increase road construction and timber harvest can be expected to affect the amount of debris produced during any given unit of time, unless procedures to minimize damage are adopted.

When the water velocity of a sediment-transporting stream is temporarily reduced for any reason, as by channel widening, changes in gradient, or partial blocking, deposition of sediment occurs. The aggraded condition of the channel often diverts the

PHOTO 2-10. Debris dam on North Fork Sauk River. (USFS)

eroding effect of the stream to one side or the other of the channel. Progressive blockages and resulting erosion and sediment conditions may induce the stream to lengthen its course by successive curves or "meanders."

In a meandering stream, most of the bank-cutting is found on the outside of the curve. This cutting may continue at the same time that shoaling is occurring from sediment deposited by lower velocities on the inside of the curve. The culmination of the meandering may be for the stream to find a new course, thus abandoning the curve. The abandoned channel thus becomes a slough through which appreciable flow occurs only during freshets. Some stream reaches exhibit multiple parallel channels, thus laying waste much of the adjacent lowland in a process known as braiding.

PHOTO 2-11. Eroding riverbank. Note bank cutting on outside of curve and shoal formation. (SCS)

Significant bank erosion and channel braiding conditions exist on streams of the Puget Sound Area and are recognized as high producers of channel sediments. Two estimates are presented of the aggregate length of channel banks thus affected:

1. This study utilized local knowledge combined with map measurements of recent aerial photography. Figures were expanded to obtain roughly significant estimates of bank erosion, and indicated that 1,065 miles of stream channel were affected by moderate to severe erosion (see Table 2-5).

2. An independent estimate prepared for the National Assessment of Streambank Erosion (1969) utilized a mathematical approximation. A factor of 0.97 was used to represent the estimated average number of miles of channel per square mile of land area draining not less than one square mile (see Erosion Progression). Computations based on this assumption indicated a total of 13,433 miles of stream channel of the size indicated, and further estimated 1,362 miles of significant channel bank erosion.

PHOTO 2-12. Roadbuilding exposes many sediment sources. (USFS)

Consideration of the two estimates leads to the inference that in the Puget Sound Area there exists at least 1,000 miles of bank erosion having a degree of severity warranting corrective measures. About five percent of the equivalent streambanks of the Area thus need rehabilitation and protection. This is in addition to bank erosion on streams of lesser size and greater drainage density not considered by either estimate.

TABLE 2-5. Stream channel braiding and erosion[1]

| Measured River Reach | Braiding (feet) | Bank Erosion Severe (feet) | Bank Erosion Moderate (feet) |
|---|---|---|---|
| **Nooksack** | | | |
| Main Stem | 56,200 | 48,600 | 67,100 |
| North Fork | 78,700 | 1,000 | 8,300 |
| South Fork | 26,500 | 4,000 | 6,000 |
| Middle Fork | 29,600 | 36,200 | 12,200 |
| Total Nooksack | 191,000 | 89,800 | 93,600 |
| **Skagit** | | | |
| North Branch | 0 | 0 | 17,200 |
| South Branch | 0 | 0 | 16,600 |
| Main Stem | 24,400 | 89,200 | 28,000 |
| Total Skagit | 24,400 | 89,200 | 61,800 |
| **Stillaguamish** | | | |
| Main Stream | 8,000 | 35,500 | 23,000 |
| North Fork | 0 | 115,000 | 19,000 |
| South Fork | 0 | 95,000 | 35,000 |
| Total Stillaguamish | 8,000 | 245,500 | 77,000 |
| **Snohomish** | | | |
| Snohomish River | 0 | 20,000 | 48,000 |
| Skykomish River | 44,000 | 35,000 | 12,000 |
| Snoqualmie River | 0 | 110,000 | 68,000 |
| Total Snohomish | 44,000 | 165,000 | 128,000 |
| **Cedar-Green** | | | |
| Cedar River | 0 | 61,900 | 32,100 |
| Duwamish River | 0 | 0 | 12,100 |
| Green River | 0 | 81,850 | 82,750 |
| Total Cedar-Green | 0 | 143,750 | 126,950 |

| Measured River Reach | Braiding (feet) | Bank Erosion Severe (feet) | Bank Erosion Moderate (feet) |
|---|---|---|---|
| **Puyallup** | | | |
| Puyallup River | 0 | 19,950 | 30,850 |
| White (& Stuck) Rivers | 77,000 | 34,800 | 42,850 |
| Total Puyallup | 77,000 | 54,750 | 73,700 |
| **Nisqually-Deschutes** | | | |
| Nisqually River | 14,350 | 52,150 | 47,150 |
| Deschutes River | 0 | 6,250 | 19,600 |
| Total Nisqually-Deschutes | 14,350 | 58,400 | 66,750 |
| **West Sound** | | | |
| Skokomish River | 5,150 | 7,600 | 7,850 |
| Hamma Hamma River | 0 | 1,700 | 1,900 |
| Duckabush River | 0 | 0 | 1,500 |
| Total West Sound | 5,150 | 9,300 | 11,250 |
| **Elwha-Dungeness** | | | |
| Dungeness River | 0 | 2,700 | 12,550 |
| Total Elwha-Dungeness | 0 | 2,700 | 12,550 |
| Measured Totals | 363,900 | 858,400 | 651,600 |
| Expanded Totals (factor 3) | 1,091,700 | 2,575,200 | 1,954,800 |
| Expanded Totals in Miles | 207 | 488 | 370 |

[1] Measured from aerial photographs. Figures expanded on judgment basis.

**PHOTO 2-13. Sediment and debris in the Nooksack River channel. (SCS)**

Numerous short reaches of streambank have had some degree of protection installed. These measures generally consist of rock riprap or other material placed on or along seriously eroding banks. The protection generally does considerable good in protecting adjacent property from land loss, but has had relatively small effect on reducing sediment production from streambank erosion. Smaller streambanks have been protected by vegetative means. All sources of sediment need further study with a view of evaluating long-term damages resulting from sediment and with developing corrective measures.

## Sediment Movement

The sediment that passes any inventory point in a stream satisfies two conditions: first, it must have eroded somewhere in the watershed upstream of the

point; and second, it must be transported by the flow from the point of erosion to the check point. Similarly, one of two conditions limits the amount of sedment: (1) the ability of the stream to transport the sediment, or (2) the availability of the material.

For all practical purposes, the sediment load of streams can be divided into two types–bedload and suspended load. This division is based more on mode of transportation than on grain size. Bedload sediment is moved by traction and the particles are rolled, pushed, or bounced along the bed. Suspended load is carried in suspension and the particles do not come in contact with the bed for any measurable period of time. Colloids, clay, and silts are usually fairly evenly distributed in the cross section of flow. Sands, gravels, and cobbles are usually concentrated near the bed.

The movement of sediment has a significant effect on damages caused by floods and on other economic losses in rivers, harbors, reservoirs, and shoaling areas. The sediment transport has the general effect of reducing channel flood capacity, and increasing stream meander tendencies.

The analysis and measurement of sediment transport by streams is complex. Measurements of sediment movement are inadequate for conditions in the Puget Sound Area.

Flows of nearly all basin streams vary widely, with the result that the bedload in a given river reach is acted upon by widely varied forces over short periods of time. Movement of bedload is sometimes estimated by sampling with traps or by observing migration of shoals under certain conditions.

**PHOTO 2-14. Sediment accumulations are shown in this Skagit County panorama. (SCS)**

## Sediment Damage

An obvious damage resulting from sediment transport is the filling of reservoirs and, in some cases, lakes located on the stream. In the design of reservoirs, it is necessary to estimate loss of capacity by sediment accumulations during the life of the structure and to compensate in some way for the loss, either by providing an initial excess capacity in the reservoir or by providing sediment storage upstream of the reservoir. Sometimes such estimates of sediment are based on existing delivery rates projected into future years without adequate consideration of sheet erosion on watershed lands or potential transformations of drainage geometry resulting from changes in land use or changes caused by construction, natural disasters, and land management. These changes have the potential for greatly increasing the delivery rates.

Most of the major existing reservoirs appear to be located upstream of probable intensive urban developments but may be affected by increased recreational use of watershed lands, disturbance from timber harvest, construction, and forest fires. Present rates of sedimentation are relatively low at the elevations of these reservoirs, but large areas of land above the reservoirs have a severe erosion potential. Prudence requires good management of these lands to prevent serious damage to the effectiveness of the reservoir sites.

Sediment damages, less obvious than the classic problem of reservoir site depreciation but probably of greater economic and environmental magnitude, are caused to the system of streams in each basin. Suspended sediments contribute to erosion of hydraulic machinery, damage irrigation and industrial equipment, and pollute the water in a variety of ways that affect the environment and detract from many of the useful purposes of the water. Sediment loads frequently are deposited on valuable farm land and developed areas with considerable loss of land and other property. Sediment often damages drainage structures and spawning areas for fish; adversely affects recreation and esthetic values; causes loss to navigation facilities and other improvements; and changes estuarine areas. Further study is needed to evaluate long-term effects of sediment movement and to develop improved methods of mitigating these effects.

The flooding, swamping, and other direct and indirect damages may be subject to further gross increases if highly developed areas are unwisely

located where damages may occur or if unwise management of watershed areas allows sediment loads to increase materially from large areas of vulnerable land.

Likewise, attention to fairly obvious streambank erosion should not lead to neglect of the less obvious sheet erosion and transformations of drainage geometry located at points somewhat remote from the main stream. Such transformations may result from changes in land use or changes in conditions caused by construction, natural disasters, and management. Although the total impact on environment may be greater, many of these changes occur gradually and thus escape attention until definite changes in the environment have occurred.

A material increase in the delivery of sediment from offsite sources has the possibility of invalidating original estimates of sediment volume. The most economic and effective measure against these sediment-accelerating influences appears to be the maintenance of good vegetative cover on the watershed lands, combined where necessary with specific conservation treatment. In the upper forested areas this work is largely preventive in nature and consists of adequate fire protection, careful regulation of logging practices, and care in the location and construction of roads, combined with specific structural and vegetative measures to repair critical erosion conditions resulting from natural causes or inadequate judgment in construction.

Historically, consideration of sediment delivery of streams has been confined to estimating effects on reservoir storage. Comparatively less attention has been given to damages caused by sedimentation of free-flowing streams, rivers, and estuaries because the damage, while probably greater in total cost in dollars and lost environment, is diffused among multiple interests and attracts less attention.

The future condition of these lands depends almost entirely on management. The upper mountainous areas are largely in Federal ownership and presumed likely to remain in relatively good condition provided current management practices are continued. The same can be said of extensive areas managed by the State of Washington. Management, while good, could be improved in many ways to lessen sediment production or to accomplish other beneficial results. In general, management improvement will depend on definition and establishment of objectives for public management and availability of funds.

Much of the private forest lands and croplands are managed by private enterprise. The amount of funds voluntarily invested by the owner in improvements varies with the means and policy of the individual. Production management is not always good watershed management. In general, conditions that contribute to a moderate and stable income from the land contribute to good management, while conditions that encourage speculation or profit-taking and exploitation cause poor management.

Some degree of sediment production and movement is natural and, in fact, essential for ecological balance. Sediment particles in many cases carry adsorbed nutrient materials that are an essential part of the food chain. A degree of deposition and natural shoaling of bed-load sediment in streams and estuaries create desirable habitat conditions for various forms of aquatic life. Sediment deposition along coastal landforms is the chief source of beaches and shallows that offer numerous benefits. It is the excessive movement of sediments that becomes damaging and is the concern here. Efforts to control sediment production refer only to accelerated production of sediments above the normal.

Many kinds of sediment may be classified. A common classification is by size and is useful for computing characteristics of movement. Other classifications, often neglected, are based on biological, physical, and chemical properties. Many sediments have a large capacity for adsorption of nutrient materials, pollutants, and various gases. The character of sediments varies with the source and with the classification of particle size caused by transporting by water. Characteristics of sediment may change rapidly in areas where disturbances are caused by construction or urban influences, and these changes are inadequately known.

The extent and widespread consequences of rural and urban sediment production and delivery need further study in the Puget Sound Area. The study should consider sources and control measures and evaluate significant properties of sediment that affect economic and environmental qualities of the Area. Many of the physical, chemical, and biological aspects of sediment classification and its derivation, movement, and disposition require evaluation beyond the comprehensiveness and intensity currently accomplished. The study may require monitoring and analysis of these conditions over an extended period of time. However, a preliminary report should be made available before 1980.

# FLOODWATER DAMAGES

## GENERAL

Areas subject to floodwater damages are estimated by soil interpretation and by consideration of historical records. A total of 747,000 acres are found subject to floodwater damages at least once in 100 years from excess precipitation and other causes. About 276,800 acres of the total are subject to damages by overbank flooding of major streams, in addition to other sources of damaging water. The area subject to damages is comprised of approximately 190,800 acres of forest and range land, 454,400 acres of cropland, and 101,800 acres of urban and rural non-farm land. Damages from floodwater are estimated at $15,954,000 annually and will increase rapidly with time if urban development of hazardous areas is permitted to continue in accordance with present trends. About $7,132,000 of the above damages are from overflow of principal rivers and $8,822,000 from tributary and upstream flood plains.

Values used in determining floodwater damages are derived from historical data prepared for Appendix XII, Flood Control. Average annual damage per acre within the Area may vary by basins from a low of $3.88 in the Nisqually to a high of $39.15 in the Snohomish. Historical average annual damages on the 276,800 acres in the flood plains of major streams were considered typical of damages in the tributary or upstream flood plains, and thus are used to estimate damages on 470,200 acres of upstream and tributary flood plains.

The best cropland is contained in these flood plains. Reserving use of the flood plains for farming, other open uses, and certain water-based industries, offers advantages in limiting escalation of future damages.

## DAMAGE REDUCTION METHODS IN USE

### Regulation of Use

Much voluntary regulation of use is practiced by landowners and operators to limit damages in flood-prone areas. These measures usually include planning vegetative cover and crop rotations to furnish protection against land scour, as well as location of buildings and other improvements to minimize loss. Concern is felt in many localities that urban development will further encroach onto hazard areas. Steps toward regulation of use by county and State ordinances are being considered in several basins.

### Flood Control Measures

This is the term generally applied to works of the type installed by the United States Army Corps of Engineers through its civil works program to mitigate damages caused by overbank flooding of principal rivers. Measures generally consist of flood detention storage, levees, and river channel improvements. Some flood storage is provided in the Puget Sound Area by Ross Dam on the Skagit River, Howard A. Hanson Dam on the Green River, and Mud Mountain Dam on the White River. Incidental floodwater storage is provided through hydroelectric and water supply storage projects on the Skagit, Cedar, Nisqually, Skokomish, and Elwha Rivers. Some channel improvement is accomplished on the Skokomish River, lower Cedar River, and lower Puyallup River.

Many levees have been constructed by private parties and by local improvement districts to protect against moderate flood occurrences and tidal effects from Puget Sound. Most of these levees are constructed for protection of land in agricultural use. The level of protection obtained from many of these non-Federal improvements is against floods of a recurrence frequency of 2-8 years.

The special subject of improvements to provide protection from overflow of major streams is appropriately covered in Appendix XII, Flood Control. Flood prevention measures as distinguished from Flood Control are discussed in more detail in this Appendix. The subject of "flood control" is not duplicated here except to the extent required to explain the disposal or mitigation of comingled waters and to advance, in some instances, improvement alternatives consisting of programs and projects appropriate for agriculture and other open use of land in conjunction with regulated utilization of land in hazard areas.

### Flood Prevention Measures

Flood prevention measures are the type of improvements generally constructed under the provisions of Public Law 566 under the leadership of the Soil Conservation Service. These are undertakings for

the conveyance, control, and disposal of surface waters caused by abnormally high direct precipitation, stream overflow, or flood aggravated by wind or tidal effects.

Improvements consist of: (a) land treatment measures installed by landowners to improve soil and water resources and to provide the highest feasible degree of runoff retardation, sediment control, and water management; and (b) structural measures that produce measurable flood prevention benefits to groups of landowners, to communities, and to the general public. Structural measures are installed by local improvement districts and subdivisions of State government, with technical and financial assistance from the United States Department of Agriculture.

The following projects and treatment programs, planned under Public Law 566, have been completed or are now underway: Saar Creek (map number 11-2) in the Nooksack-Sumas Basins; French Creek (8-2), and Marshland (8-5) in the Snohomish Basin; and East Side Green River (0-34), and West Side Green River (0-35) in the Green River Basin. When installed and fully operative, these projects are planned to produce over $1,686,000 of direct flood damage reduction and other benefits, per year. Other projects that appear feasible for early action are discussed in the section "Means to Satisfy Needs" of this Appendix.

Flood prevention measures are applied mainly to reduce damages from watersheds smaller in size than those discussed under Flood Control, and normally are applied as parts of multiple-purpose projects. Such projects may include community drainage and other water management purposes; and purposes such as recreation, fish and wildlife habitat improvement, and water supply in addition to flood prevention.

Each small tributary to a large stream adds its increment to the volume of water in the river on its way toward Puget Sound. The quantity of these flows and the time of concentration at the main stream are of importance in computing the size of a flood on the main stream. This is especially true if the tributary stream is large or there are a number of small streams.

The application of land treatment measures designed to retard the runoff from small watersheds or the construction of reservoirs may change both the size of peak flows and the timing of peak flows from small watersheds. Channel improvements, urbanization, industrialization, and pumping from small watersheds tend to increase the volume of runoff and the flood peaks.

Small streams frequently are relatively large contributors of sediment and pollution into the main channel. The sediment may fill or block the main channel, causing floods, even at lower peak volumes of flow than usually experienced. The control of sediment sources is an urgent need.

Works of improvement installed in approved watershed project areas to control the flows from small streams frequently add much to the esthetic values and lead to many recreational possibilities. Properly applied land treatment measures lead to increased and more efficient agricultural production. These same land treatment measures provide community-wide benefits through improved water management, and decreased sediment and other pollution.

Flood prevention measures and flood control measures often are complementary in nature and both types of measures frequently are necessary in providing flood damage reduction benefits on tributary streams and improved drainage and other benefits to flood plain lands. Coordination in installing projects is accomplished by planning guided by an agreement between the departmental agencies.

Several categories of flood prevention measures are described here. These methods are sometimes combined to obtain practical benefits at minimum expense.

**Watershed Use and Treatment**—Watershed use, and treatment of the watershed according to its use, is of particular importance. Agronomic and forestry management, and measures to retard the outflow of water and minimize the production and transport of sediment are very important. Typical practices involve keeping the maximum area of the watershed in vegetative cover of grass, shrubs, and forest. Where sloping land must be used for row crops, planting and cultivation should be accomplished on the contour; insofar as possible, critical sediment-producing areas should remain in permanent cover; and all means used to encourage infiltration of water into the soil where it may be released at a more equitable rate. In particularly critical areas, permanent terraces and furrows constructed on the contour and provided with proper outlet channels, assist in removing the excess water.

When developments, such as road construction or urban concentrations, are placed on these lands, full consideration should be given to the effects on the hydrology of the watershed. Such consideration will provide for the shortened time of concentration

of flow; decreased infiltration into the soil mantle; and less evapotranspiration. Properly designed and protected channels for disposal of excess flow should be made a part of the development and should provide for greatly increased peak demands as a direct result of the less favorable hydrologic conditions, as well as the increase in damageable values to be protected.

**Detention Storage**–Achieving protection by storage or detention when practical, frequently results in conserving water for auxiliary uses. The benefits thus achieved may include the use and enjoyment of the water for irrigation and other consumptive uses; recharge of subsurface water supply; recreation, fish and wildlife use; lowflow enhancement of streams; and other uses. Detention of peak flows, so that these volumes do not synchronize with other downstream flood peaks, sometimes will aid materially in reducing downstream flood peaks. The reduction of peak flows will also materially reduce the velocity of flows and retard erosion of streambeds, reduce the sediment carried by the stream, and help reduce bankcutting and overtopping of dikes. Storage for flood prevention purposes has not been practiced for small watersheds primarily because of the large volumes of flow encountered throughout the Area. Particularly favorable sites are necessary if flood prevention is to be accomplished primarily by storage.

Many small stream reaches have regrettably small flows or become dry during summer periods of low rainfall. Often watershed conditions contributing to high peak flows during winter months also contribute to variable low flow conditions in the summer. Lack of adquate summer and early fall flows in these streams denies the Area many benefits.

In many localities the summer flow is supported entirely by ground water contributions. In some instances actual and potential fish and wildlife, recreational, water supply, and agricultural purposes could benefit greatly by measures to improve the low flow of these streams. Each such stream requires separate study but improvements generally consist of adequate land treatement measures, channel improvements, and often controlled storage. Storage thus provided may contribute to flood prevention benefits.

**Levees, Dikes, and Bank Protection**–This general approach is commonly used because it is a relatively inexpensive method of producing benefits. Small quantities of earth, formed into levees or dikes, will assist in the conveyance of large quantities of water and will protect areas of land with a minimum of expense.

Bank protection has been provided by numerous methods for the purpose of saving land from the encroachment of the river and making an efficient channel for flow. The most practical and popular method of bank protection is to armor the streambanks with rock riprap. In the interest of economy, it is standard practice to protect with rock only those points at which most damage occurs. The combination of levees and bank protection is the most common method of flood protection and control. Vegetative protection is used for small channels and in combination with structural protection on many larger channels.

**Channel Capacity Improvement**–Channel capacity improvement is often used for control of the smallest flood problems. The smaller streams generally have inadequate channels; this is especially true of the flatter lands or in the hummocky types of terrain. On the smaller streams the principal purpose is often to remove excess water from the land, and the formation of natural or constructed levees along a channel prevents local waters from readily entering the stream. When this condition and purpose exist, it is common practice for the stream channel itself to be deepened and/or widened, and the spoils spread on land adjacent to the channel in such a way that they will not interfere with local waters entering the channel.

New channel construction is sometimes required to facilitate removal of waters trapped by topographic features or by construction along major channels. Floodgates installed for outlet of waters collected by these channels serve to allow outflow during low stages of rivers and to prevent reverse flow during high stages. In some cases discharge works require the use of pumps for discharge of collected waters under conditions of adverse hydraulic head.

## DEMANDS FOR FLOOD PLAIN USE

The level of flood protection required varies widely, depending upon location; soil type, and soil stability; the type of land use; and the gradient or slope of the land. Homesites, industrial complexes, and urban areas require a high degree of protection. Schools, public buildings, and commercial areas require almost complete protection from all types of flooding, including standing water or ponding.

Land for certain farming uses can tolerate occasional flooding during dormant or non-growing seasons, provided the duration of flooding is short. Agricultural areas located where the flow of the water is swift, or where the soil is vulnerable can stand very little flooding. Floodwaters which are swift, erosive, or occur during the growing season, are very damaging to agricultural interests. Those floods which quietly inundate areas to a shallow depth and do not continue to inundate the area for long periods of time cause relatively small damage during the dormant season.

The relatively level flood plains of the major rivers have from early times attracted water-oriented industry, commerce, transportation, and other urban developments. Some such developments locate here by necessity; others are attracted by the level easily improved sites, often ignoring the risk from periodic flooding. Much of the good cropland is found in these flood plains and many highly productive farms are located there.

The historical demands on flood plain lands are increasing and are accompanied by a parallel demand for lands along *tributary* streams. With the advent of better roads many urban developers are becoming interested in formerly remote stream valleys tributary to the main stem rivers. Much of the interest stems from a search for cheap land to develop and for suburban acreage. Along with increasing population is a demand for development of recreation areas enhanced by small streams.

The increased use of these upstream areas has greatly increased the conservation problem. Sediment production for the urbanization and building activities which are taking place is causing sediment problems downstream and within the small watersheds themselves. The more rapid and increased runoff from these areas is adding to the previous peak flows of some streams. Channel capacities are reduced by the sediment eroded from the watersheds and deposited in the streams.

An average of 6,000 acres per year of cropland was converted to urban uses during the period 1949-1964. Of this amount, about 1,000 acres per year are estimated to consist of the better quality cropland of the flood plains of rivers and tributaries. The rate of loss of the better quality cropland is expected to increase rapidly to an annual rate of 5,000 to 6,000 acres per year by 1980 unless the present trend of urban scattering is modified. The result, if the present trend continues, will be a large loss of productive values and a greatly increased cost in providing protection against damages associated with occupancy of flood plain lands.

## LAKES AND POTENTIAL RESERVOIR SITES

Fresh water lakes are features of the landscape that have been formed by any of several geologic processes; e.g., land rising or subsiding, volcanic activity, river erosion, landslides, and glacial action. Glacial action, in particular, has been active, directly or indirectly, in forming lowland lakes found at elevations below 3,000 feet as a result of ice erosion, morainal dams in valleys, or the formation of kettles.

There are over 2,800 lakes in the Puget Sound Area.[1] About half of the lakes have a surface area of less than five square miles, and all the lakes are relatively small. Some of the lakes are provided with outlet controls for the purpose of modifying their size or depth, or for regulation purposes.

The shores of easily accessible lakes have become favored residential sites and the lakes are coming under increasing recreational use. Many of these installations depend on septic tanks and garbage dumps for waste disposal where soil conditions often are unfavorable for such uses. Poor waste disposal, combined with accelerated sedimentation, increase solar heating and lead to greatly increased loading of the lake with nutrient materials conducive to aquatic plant growth and general degradation.

Lakes, geologically speaking, are transitory features of the landscape. Once formed, they begin to pass through stages of aging described as youth, maturity, old age, and oblivion. The newly formed lake becomes at once subject to combinations of physical and biological forces that begin to age the impoundment. Soil erosion and sedimentation, wave action, lake currents, and various animal and vegetative successions, act to fill the depression or to erode the outlet. In its old age, the depression has at last

[1] Wolcott, Ernest W., *Lakes of Western Washington.* 1965.

been drained; or, alternatively, filled, becoming first a bog and ultimately a meadow. There are many "dead" lakes in the Puget Sound Area, and the life expectancy of many small lakes can be considered as relatively short.[1]

Lakes are a valuable natural resource and good management can, in many cases, restore and protect their quality for greater benefit. Structures to lessen the inflow of sediments and plant nutrients; to provide circulation and aeration of the water; to control temperature; and to stabilize outlet and inflow, as well as measures to control or modify the succession of animal and vegetable life are useful under varying conditions. Each lake is unique in size, position, and ecology so that a detailed study of the individual site is essential in providing the best management for any of several beneficial purposes. While management varies with the site, the obvious first step is to determine the objectives of management: i.e., the principal uses to which the resource is to be dedicated.

Lakes are very important in the hydrologic regimen of the Area and serve many purposes. Construction of artificial lakes and ponds frequently is undertaken and often provides benefits similar to natural lakes. Artificial lakes as well as natural lakes generally assist in the management of runoff waters and, in many instances, contribute to the low flow regimen of small streams, furnish water for various uses, and serve recreational demands.

About 24[2] of these existing reservoirs can be classed as major structures for hydroelectric power or water supply purposes, and over 1,300[3] ponds and reservoirs have been constructed for farm water supply or as recreational assets. Construction of ponds containing over ten acre-feet of storage requires permission from the State Department of Water Resources, and construction must follow sound engineering criteria.

Construction of storage, within reasonable economic criteria, requires sites that provide good foundations, good water retention characteristics, and topography adapted for storage. In addition, the site must be located so the storage, with reasonable maintenance, can provide good life expectancy. Prudence indicates the need to estimate loss of storage capacity from sediment during the life of the structure and to compensate for this loss. Estimates should be based on the total watershed environment and projections of changes. With large reservoirs, compensation for loss of capacity is often accomplished by providing an initial excess of capacity, rather than providing offsite structural measures to improve watershed conditions. In the case of smaller structures, and in the case of critical sediment-producing areas upstream of the reservoir site, auxiliary structures, such as sediment catchment basins, stabilization measures, bank revetments, channel sills, and drop structures may be economically sound. Drainage, or diversion of flows around slide areas to improve stability, may be desirable.

Major potential reservoir sites are well known and many are included in the descriptions of the various basins in Appendix III, Hydrology and Natural Environment. Reservoirs of less than major size can provide substantial benefits also, and by careful location and planning, can contribute benefits to tributary streams and in the aggregate provide considerable benefits to entire river basins. The critical need is careful detailed planning that will provide objectives and criteria for each site or group of sites considered.

Rivers and tributary streams in the Area generally have steep gradients that induce relatively high installation costs per unit of storage capacity. These comparatively high storage costs, often with high volumes of seasonal flow, have combined in the past years to limit construction of impoundments primarily for the reduction of flood damages. Of the major structures in place, only Howard A. Hanson Dam on the Green River, and Mud Mountain Dam on the White River, have flood control as the primary purpose. Numerous impoundments, however, have been constructed for hydroelectric generation, water supply, and other purposes under conditions where secondary benefits—such as flood prevention and recreation to name a few, have been realized.

This observation also applies to the construction of small impoundments where the cost per unit of storage capacity is expected to be comparatively high, causing channel improvements or other alternatives for flood prevention purposes to be generally favored, unless the storage capacity can also be used for other purposes in addition to reduction of flood

[1] Lane, Ferdinand C. As an example of relative longevity, Mr. Lane predicted that "half the lakes in Minnesota" (formed in a way somewhat similar to those in the Puget Sound Area) "will become 'dead' within fifty years."

[2] See Appendix III, Hydrology and Natural Environment.

[3] From records of the Soil Conservation Service (1966).

damages. Small impoundments for water supply, special recreation site development, fish and wildlife purposes, and lowflow augmentation of tributary streams, may singly or in combination provide feasible bases for construction of numerous small impoundments in future years.

The climatic characteristics of the Puget Sound Area cause minimum flow in most streams to occur between June and November. This characterisitc is particularly prominent in low-lying watersheds that derive much of their summer flow from ground water storage. The low flow of these streams is a limiting factor in the full development of many resource values of the Area. Numerous small impoundments, located in the headwater reaches of low-lying streams, or in favorable off-stream sites, have the potential of providing controlled storage of winter runoff to augment critical low flow in the summer. The low flow characteristics of Area streams are discussed by river basins in Appendix III, Hydrology and Natural Environment.

Storage to augment low flows of streams has not been used in this Area to the extent needed to fully evaluate benefits. Storage for this purpose, and for purposes such as recreation site development, needs to be carefully analyzed on a site basis; thus generalizations at this time are unwarranted. It is believed that such developments will be few in number until after 1980, after which numerous storage installations may prove feasible. Further evaluation needs to be undertaken in the near future so that criteria may be developed by 1980.

In recognition of the fact that smaller reservoir sites are a scarce natural resource in the Puget Sound Area, a map study was undertaken to identify potential sites. No estimate of benefits has been made. Costs of impoundments vary widely but are expected to be from $250 up per acre-foot (1968 prices), depending on site conditions and location.

A partial list of potential sites for further investigation is given in Table 2-6 in order to widen consideration of potential utilization of this resource. Most of the sites listed are in the lower foothills zone of the Cascade and Olympic Mountains; a few are on the San Juan Islands.

Similar sites exist at higher elevations but have not been listed because of their greater distance from watershed reaches expected to be benefited. Some of the natural lakes, not listed, may have potential for structural improvement and control of storage with beneficial results.

**PHOTO 2-15. Cleared area is being prepared for housing development in King County. Note erosion of cleared area and loose fill in foreground. Much loss of soil could be prevented by seeding cover crop and providing drainage for storm water. (SCS)**

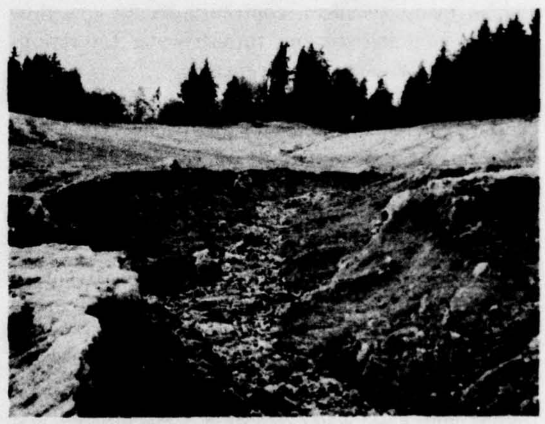


**PHOTO 2-16. Same area as Photo 2-15. The gully at this point is about eight feet deep and 50 feet wide. The soil lost from this area eventually may end up in Lake Washington where it will contribute to degradation of the lake. (SCS)**

## TABLE 2-6. Potential reservoir sites by basins, Puget Sound Area[1]

| Basin and Watershed | Water-shed No. | Location: Sec. | Location: Twp. | Location: Rge. | Estimated Size: Top Length (feet) ± | Estimated Size: Height (feet) ± | Estimated Size: Storage Capacity (ac. ft.) ± |
|---|---|---|---|---|---|---|---|
| **NOOKSACK-SUMAS BASINS** | | | | | | | |
| N. Fork Nooksack R. | 10-1 | 30 | 40N | 6E | 650 | 35 | 23,000 |
| Middle Fork " " | 10-2 | 30 | 39N | 6E | 600 | 30 | 17,500 |
| Anderson Creek | 10-5 | 8 | 38N | 4E | 450 | 30 | 4,000 |
| Bertrand-Fishtrap Cr. | 10-6 | 3 | 40N | 2E | 550 | 15 | 1,600 |
| Wiser Lake-Tenmile | 10-7 | 21 | 39N | 2E | 150 | 15 | 1,000 |
| | | 22 | 39N | 3E | 650 | 25 | 7,500 |
| | | 9 | 39N | 3E | 700 | 15 | 1,000 |
| | | 30 | 39N | 3E | 750 | 20 | 2,500 |
| Saar Creek | 11-2 | 13 | 40N | 4E | 800 | 40 | 15,000 |
| Dakota Creek | 0-1 | 8 | 40N | 1E | 450 | 20 | 4,500 |
| Terrell Creek | 0-3 | 1 | 39N | 1W | 350 | 15 | 1,500 |
| | | 6 | 39N | 1E | 170 | 25 | 500 |
| | | 4 | 39N | 1E | 100 | 17 | 1,200 |
| California Creek | 0-4 | 18 | 40N | 1E | 300 | 15 | 1,500 |
| Silver Creek | 0-5 | 4 | 38N | 2E | 500 | 20 | 1,650 |
| Chuckanut Mountain | 0-8 | 14 | 36N | 3E | 500 | 40 | 700 |
| | | 26 | 32N | 6E | 100 | 20 | 300 |
| **SKAGIT-SAMISH BASINS** | | | | | | | |
| Baker River | 9-2 | 16 | 36N | 8E | 350 | 20 | 50 |
| North Skagit Tribs. | 9-6 | 28 | 36N | 8E | 500 | 20 | 500 |
| | | 5 | 35N | 7E | 350 | 30 | 100 |
| | | 11 | 35N | 6E | 400 | 20 | 50 |
| South Skagit Tribs. | 9-7 | 32 | 35N | 5E | 2,600 | 60 | 3,000 |
| | | 16 | 34N | 6E | 600 | 30 | 500 |
| | | 15 | 34N | 8E | 500 | 25 | 1,000 |
| | | 29 | 34N | 9E | 400 | 30 | 1,000 |
| | | 25 | 35N | 8E | 550 | 40 | 10,000 |
| | | 14 | 34N | 6E | 300 | 20 | 500 |
| Nookachamps | 9-9 | 8 | 34N | 5E | 650 | 50 | 4,500 |
| | | 23 | 34N | 4E | 600 | 60 | 3,000 |
| | | 32 | 35N | 5E | 400 | 30 | 20 |
| | | 25 | 34N | 4E | 300 | 50 | 20 |
| South Mount Vernon | 9-10 | 34 | 34N | 4E | 400 | 40 | 1,000 |
| | | 34 | 33N | 4E | 400 | 20 | 100 |
| Samish River | 0-14 | 19 | 36N | 4E | 500 | 20 | 100 |
| | | 18 | 36N | 4E | 350 | 25 | 20 |
| | | 6 | 36N | 4E | 100 | 10 | 50 |
| | | 6 | 36N | 4E | 100 | 10 | 100 |
| | | 29 | 36N | 4E | 400 | 45 | 180 |
| | | 24 | 36N | 3E | 400 | 20 | 100 |
| | | 21 | 36N | 4E | 300 | 20 | 50 |
| **STILLAGUAMISH BASIN** | | | | | | | |
| N. Fork Stillaguamish | 0-17 | 30 | 32N | 8E | 300 | 35 | 1,300 |
| | | 27 | 32N | 6E | 150 | 15 | 30 |
| | | 5 | 32N | 7E | 500 | 30 | 200 |
| | | 10 | 31N | 6E | 400 | 20 | 100 |
| | | 17 | 32N | 8E | 300 | 20 | 100 |
| | | 16 | 32N | 9E | 300 | 30 | 300 |
| | | 9 | 32N | 9E | 300 | 40 | 400 |
| S. Fork Stillaguamish | 0-18 | 5 | 30N | 7E | 400 | 30 | 400 |
| | | 8 | 30N | 7E | 500 | 50 | 500 |
| | | 15 | 30N | 7E | 100 | 20 | 50 |
| | | 9 | 29N | 7E | 150 | 40 | 150 |
| Jim Creek | 0-19 | 17 | 31N | 6E | 400 | 50 | 150 |
| | | 27 | 31N | 6E | 300 | 20 | 50 |
| | | 22 | 31N | 6E | 500 | 30 | 300 |
| Pilchuck Creek | 0-20 | 10 | 32N | 5E | 400 | 30 | 40 |
| | | 22 | 33N | 5E | 400 | 35 | 200 |
| Lower Stillaguamish | 0-21 | 23 | 32N | 5E | 300 | 30 | 100 |
| Church Creek | 0-22 | 29 | 32N | 4E | 300 | 30 | 25 |
| | | 10 | 32N | 4E | 150 | 20 | 20 |
| | | 3 | 32N | 4E | 350 | 20 | 25 |
| **SNOHOMISH BASIN** | | | | | | | |
| Snoqualmie River | 8a | 8 | 25N | 8E | 550 | 50 | 2,570 |
| | | 9 | 25N | 8E | 100 | 30 | 276 |
| | | 19 | 25N | 8E | 700 | 30 | 4,500 |
| | | 33 | 25N | 8E | 450 | 50 | 3,300 |
| | | 25 | 25N | 7E | 700 | 40 | 2,800 |
| | | 9 | 24N | 8E | 400 | 40 | 1,760 |
| | | 33 | 26N | 7E | 300 | 40 | 1,200 |
| Skykomish River | 8b-1 | 15 | 27N | 8E | 200 | 5) | 3,200 |
| | | 21 | 27N | 8E | 600 | 65) | |
| | | 15 | 27N | 7E | 200 | 35 | 600 |
| Woods Creek | 8b-4 | 3 | 28N | 7E | 400 | 20 | 500 |
| | | 10 | 28N | 7E | 300 | 15 | 500 |
| | | 30 | 29N | 6E | 200 | 20 | 200 |
| | | 26 | 28N | 7E | 100 | 30 | 100 |
| Pilchuck River | 8-1 | 28 | 30N | 6E | 60 | 15 | 25 |
| | | 16 | 30N | 6E | 300 | 20 | 30 |
| **CEDAR-GREEN BASINS** | | | | | | | |
| Sammamish River | 0-30 | 6 | 26N | 6E | 200 | 24 | 75 |
| | | 3 | 26N | 7E | 350 | 38 | 490 |
| | | 21 | 26N | 6E | 250 | 40 | 880 |
| | | 16 | 26N | 7E | 400 | 50 | 970 |
| | | 17 | 23N | 6E | 1,100 | 40 | 5,450 |
| | | 6 | 22N | 7E | 600 | 30 | 770 |
| | | 36 | 23N | 6E | 550 | 40 | 880 |
| East Side Green R. | 0-34 | 3 | 21N | 5E | 200 | 40 | 433 |
| | | 3 | 21N | 5E | 150 | 18 | 35 |
| Upper Green River | 0-37 | 10 | 20N | 6E | 500 | 25 | 275 |
| **PUYALLUP BASIN** | | | | | | | |
| White River | 7-1 | 7 | 19N | 7E | 200 | 20 | 40 |
| Puyallup River | 7-3 | 13 | 20N | 3E | 300 | 60 | 30 |
| | | 3 | 19N | 4E | 200 | 12 | 50 |
| | | 30 | 20N | 3E | 250 | 20 | 30 |
| | | 34 | 20N | 3E | 400 | 60 | 50 |
| | | 8 | 18N | 5E | 300 | 30 | 25 |
| | | 24 | 20N | 3E | 400 | 60 | 50 |
| | | 7 | 19N | 5E | 1,000 | 100 | 1,500 |
| | | 14 | 20N | 3E | 300 | 60 | 30 |
| | | 36 | 19N | 4E | 150 | 25 | 40 |
| South Prairie Creek | 7-4 | 17 | 19N | 6E | 500 | 20 | 150 |
| | | 27 | 19N | 6E | 500 | 80 | 500 |
| | | 8 | 16N | 6E | 1,000 | 100 | 1,500 |
| Fort Lewis-Tacoma | 0-40 | 22 | 19N | 1E | 500 | 20 | 30 |
| **NISQUALLY-DESCHUTES BASINS** | | | | | | | |
| Horn-Tanwax Creek | 0-42 | 31 | 17N | 4E | 250 | 20 | 20 |
| | | 16 | 16N | 3E | 1,500 | 50 | 1,000 |
| | | 21 | 16N | 3E | 300 | 60 | 50 |
| Ohop Creek | 0-43 | 14 | 16N | 4E | 300 | 40 | 30 |
| | | 3 | 16N | 4E | 120 | 30 | 25 |
| | | 26 | 17N | 4E | 200 | 40 | 25 |
| Nisqually River | 0-45 | 1 | 16N | 2E | 500 | 80 | 100 |
| | | 7 | 16N | 2E | 250 | 8 | 35 |
| | | 30 | 16N | 3E | 200 | 20 | 200 |
| Deschutes River | 0-46 | 32 | 17N | 1W | 150 | 10 | 125 |
| Henderson Inlet Area | 0-47 | 6 | 18N | 1W | 100 | 10 | 30 |
| | | 4 | 18N | 1W | 150 | 12 | 70 |
| West Budd Inlet Area | 0-48 | 4 | 18N | 2W | 100 | 35 | 25 |
| **WEST SOUND BASINS** | | | | | | | |
| Skookum Creek | 0-49 | 3 | 18N | 3W | 100 | 10 | 160 |
| | | 2 | 18N | 4W | 150 | 30 | 200 |
| | | 22 | 18N | 3W | 200 | 15 | 200 |
| McNeil Island | 0-52 | 17 | 20N | 1E | 750 | 80 | 200 |
| Northwest Shelton | 0-55 | 25 | 23N | 1W | 360 | 30 | 380 |
| | | 34 | 23N | 1W | 265 | 50 | 320 |
| | 0-62 | 5 | 20N | 1W | 300 | 40 | 50 |
| | | 28 | 21N | 1W | 500 | 50 | 400 |
| | | 4 | 20N | 1W | 300 | 20 | 25 |
| | | 9 | 22N | 1E | 300 | 30 | 2,800 |
| East Hood Canal | 0-68 | 21 | 24N | 2W | 360 | 50 | 2,700 |
| | | 21 | 24N | 2W | 490 | 100 | 5,500 |
| | | 9 | 24N | 2W | 820 | 120 | 2,600 |
| | | 36 | 25N | 2W | 650 | 90 | 6,200 |
| | | 35 | 25N | 2W | 650 | 140 | 1,700 |
| | | 31 | 25N | 1W | 660 | 100 | 1,800 |
| | | 5 | 24N | 1W | 165 | 30 | 800 |
| | | 34 | 25N | 1E | 330 | 30 | 70 |
| | | 22 | 25N | 1E | 60 | 20 | 130 |
| | | 8 | 25N | 1E | 730 | 70 | 2,000 |
| | | 17 | 25N | 1E | 485 | 25 | 60 |
| | | 12 | 24N | 1W | 430 | 100 | 1,400 |
| | | 12 | 24N | 1W | 530 | 30 | 2,000 |
| | | 12 | 24N | 1W | 360 | 30 | 1,700 |
| | | 32 | 24N | 1E | 660 | 130 | 2,000 |
| East Kitsap Area | 0-70 | 34 | 24N | 1E | 450 | 50 | 700 |
| | | 22 | 23N | 1E | 230 | 70 | 350 |
| | | 35 | 24N | 1E | 560 | 100 | 1,700 |
| | | 25 | 24N | 1E | 130 | 30 | 130 |
| | | 21 | 24N | 2E | 300 | 50 | 1,000 |
| | | 4 | 23N | 2E | 230 | 40 | 190 |
| | | 3 | 23N | 2E | 300 | 60 | 210 |
| | | 2 | 25N | 2E | 165 | 20 | 45 |
| | | 15 | 25N | 2E | 100 | 20 | 260 |
| | | 26 | 25N | 2E | 240 | 40 | 120 |
| | | 35 | 25N | 2E | 130 | 20 | 15 |
| | | 29 | 27N | 2E | 660 | 80 | 20,000 |
| | | 30 | 26N | 2E | 230 | 70 | 600 |
| | | 25 | 26N | 1E | 300 | 60 | 320 |

## TABLE 2-6. Potential reservoir sites by basins, Puget Sound Area[1] (Cont'd)

| Basin and Watershed | Watershed No. | Location: Sec. | Location: Twp. | Location: Rge. | Estimated Size: Top Length (feet) ± | Estimated Size: Height (feet) ± | Estimated Size: Storage Capacity (ac.ft.) ± |
|---|---|---|---|---|---|---|---|
| <u>WEST SOUND BASINS (CON.)</u> | | | | | | | |
| Quilcene | 0-71 | 13 | 26N | 2W | 250 | 20 | 40 |
| | | 9 | 27N | 2W | 750 | 20 | 480 |
| | | 27 | 28N | 2W | 500 | 40 | 320 |
| East Jefferson | 0-72 | 34 | 28N | 1W | 250 | 20 | 80 |
| | | 2 | 29N | 2W | 500 | 40 | 240 |
| | | 13 | 27N | 1W | 250 | 20 | 80 |
| | | 29 | 28N | 1E | 500 | 40 | 480 |
| | | 7 | 27N | 1W | 250 | 20 | 30 |
| | | 27 | 29N | 2W | 1,000 | 120 | 5,760 |
| | | 11 | 28N | 2W | 500 | 40 | 320 |
| Chimacum | 0-73 | 4 | 28N | 1W | 330 | 40 | 360 |
| | | 1 | 28N | 1W | 500 | 40 | 320 |
| Sequim Bay Area | 0-75 | 28 | 30N | 2W | 250 | 20 | 120 |
| | | 13 | 29N | 3W | 300 | 75 | 50 |
| <u>ELWHA-DUNGENESS BASINS</u> | | | | | | | |
| McDonald Creek | 0-78 | 5 | 30N | 4W | 700 | 100 | 250 |
| | | 8 | 30N | 4W | 500 | 75 | 150 |
| | | 17 | 30N | 4W | 400 | 100 | 150 |
| | | 20 | 30N | 4W | 400 | 100 | 150 |
| Siebert Creek | 0-79 | 11 | 30N | 5W | 500 | 100 | 200 |
| | | 11 | 30N | 5W | 500 | 100 | 200 |
| | | 23 | 30N | 5W | 400 | 100 | 150 |
| | | 26 | 30N | 5W | 400 | 100 | 150 |
| Morse Creek | 0-80 | 33 | 30N | 5W | 300 | 75 | 50 |
| | | 32 | 30N | 5W | 700 | 100 | 200 |
| | | 20 | 30N | 5W | 1,000 | 100 | 300 |
| | | 17 | 30N | 5W | 1,000 | 100 | 400 |
| Ennis Creek | 0-81 | 12 | 30N | 6W | 400 | 100 | 75 |
| | | 13 | 30N | 6W | 400 | 100 | 75 |
| | | 14 | 30N | 6W | 300 | 75 | 50 |
| | | 3 | 29N | 6W | 300 | 100 | 50 |
| Port Angeles | 0-82 | 9 | 30N | 6W | 300 | 100 | 50 |
| | | 30 | 30N | 6W | 500 | 100 | 100 |
| Elwha River | 0-83 | 25 | 30N | 7W | 500 | 100 | 100 |
| | | 27 | 30N | 7W | 500 | 100 | 100 |
| | | 15 | 30N | 7W | 100 | 125 | 10,000 |
| | | | 29N | 7W | 1,500 | 200 | 10,000 |
| <u>SAN JUAN ISLANDS</u> | | | | | | | |
| Orcas-Waldron Is. | 0-11 | 32 | 36N | 2W | 100 | 10 | 20 |
| | | 33 | 36N | 2W | 180 | 30 | 30 |
| | | 4 | 35N | 2W | 300 | 16 | 20 |
| | | 33 | 37N | 2W | 150 | 18 | 15 |
| | | 7 | 37N | 1W | 350 | 10 | 40 |
| | | 3 | 36N | 1W | 160 | 25 | 20 |
| | | 26 | 37N | 1W | 300 | 16 | 40 |
| | | 25 | 37N | 1W | 100 | 8 | 16 |
| | | 2 | 36N | 2W | 200 | 15 | 20 |
| | | 22 | 36N | 2W | 180 | 28 | 40 |
| San Juan (Stewart) | 0-12 | 21 | 35N | 3W | 2,000 | 25 | 6,250 |
| | | 9 | 35N | 3W | 400 | 14 | 3,000 |
| | | 1 | 35N | 4W | 500 | 12 | 400 |
| | | 7 | 35N | 3W | 200 | 25 | 25 |
| | | 7 | 35N | 3W | 200 | 25 | 25 |
| | | 7 | 35N | 3W | 200 | 25 | 25 |
| | | 7 | 35N | 3W | 200 | 25 | 25 |
| | | 17 | 35N | 3W | 250 | 18 | 35 |
| | | 9 | 35N | 3W | 200 | 20 | 150 |
| | | 2 | 35N | 4W | 250 | 35 | 70 |
| | | 18 | 35N | 4W | 300 | 20 | 100 |
| | | 12 | 35N | 4W | 500 | 10 | 100 |
| | | 29 | 35N | 3W | 200 | 22 | 150 |
| | | 12 | 35N | 3W | 150 | 15 | 20 |
| | | 12 | 35N | 3W | 150 | 14 | 30 |
| | | 29 | 36N | 3W | 150 | 15 | 300 |
| | | 5 | 35N | 3W | 200 | 30 | 20 |
| | | 17 | 35N | 3W | 190 | 15 | 35 |
| Lopez-Blakely-Decatur Islands | 0-13 | 13 | 35N | 2W | 100 | 8 | 250 |
| | | 34 | 35N | 2W | 150 | 10 | 300 |
| | | 1 | 34N | 2W | 200 | 25 | 50 |
| | | 1 | 34N | 2W | 150 | 10 | 20 |
| | | 17 | 34N | 1W | 50 | 10 | 100 |
| | | 11 | 34N | 2W | 40 | 15 | 200 |
| | | 3 | 34N | 2W | 150 | 40 | 25 |
| | | 15 | 35N | 2W | 100 | 12 | 25 |
| | | 2 | 34N | 2W | 170 | 30 | 20 |
| | | 2 | 34N | 2W | 200 | 20 | 25 |
| | | 11 | 34N | 2W | 150 | 18 | 20 |

1 This partial listing of potential reservoir sites was prepared for Puget Sound Area Study from topographic maps. Topography only was considered, and no foundation or benefit studies were made.

# DRAINAGE IMPROVEMENT

Some portions of watershed management are concerned primarily with measures for protection and rehabilitation of watershed lands. Other measures are primarily for improving land characteristics for various purposes. Drainage improvements belong in the latter category. Many opportunities exist for improvement of economic and environmental conditions in the Area, while retaining good hydrologic characteristics and soil stability in watersheds through judicious selection and use of measures in each category.

Drainage practices of various kinds are used to improve the rate and means by which excess water is removed to accommodate various purposes. Much advantage is gained by the proper selection of land suited for each developed use; in addition, the degree or intensity of drainage improvement will depend on the specific use of the land and will vary over time as successive changes in use are made. Among the purposes considered here are cropland production efficiency, urban occupancy, reduction of pollution hazard, transportation improvement, recreational site development, and vector control.

Problems of inadequate drainage were discovered when man began to cultivate the land and sought to replace native vegetation with less tolerant, but more profitable, types of vegetation. By providing simple artificial outlets and channels which would assist in removing excess water, it was found that these more economic crops could be grown in the fertile alluvial areas. Means to provide successful water management to these areas became the problem. Lack of adequate water disposal also began to interfere with other activities of man and his use of the land for living space. This led to more consideration of ways to change the environment to meet his needs.

All conditions of climate and land combine to provide certain capabilities for the removal and disposal of water that falls, or accumulates on the land. In the natural setting, evapotranspiration is the consumptive use of water and the remaining water is carried away by drainage. Drainage thus refers to the surface runoff of water, as well as to the shallow and deep percolated water that may reappear as the base flow of streams or become part of the permanent ground water province. The need for improvements to prevent damages or to secure other benefits stemming from the removal of unwanted water is considered here. These needed drainage improvements fall into two main groups: (1) those associated with the disposal of surface accumulations of water; and (2) those for collecting and removing water from within the soil mass itself for various purposes.

Surface drainage is the prevention or removal of accumulations of unwanted water, especially ephemeral floodwater, derived from excess rainfall, stream flooding, action of wind or tide, or other unusual condition.

Internal drainage—all natural soils have some inherent capacity for passing excess water through the soil mantle by the action of gravity. This ability ranges from near zero to very rapid conductivity. Improvement in this capacity for movement generally supplements the natural permeability of the soil by providing artificial conduits either to collect and remove excess water more rapidly or to intercept and divert incoming surface and subsurface flows before they saturate or damage the site to be improved. By the latter means, excessive or persistent inflow is prevented or decreased so that native drainage processes may remove the remaining unwanted water in a timely manner. Often, the two approaches are used concurrently to the extent required for a given purpose.

## UNWANTED WATER

In the settlement of the Puget Sound Area, as in most newly developed areas, land was taken by homesteading or by purchase. Speculators platted townsites, sold lots, and moved on to new places. Development of the land for changed use or improvement in use was left to the new settlers. Townsites usually were selected along the waterfronts of the bays and rivers. Inadequate knowledge about soil and water conditions, in some cases, caused unsuitable areas to be developed, resulting in expensive installations to protect the capital investment.

Excess surface and internal soil water causes property and crop damages in the Puget Sound Area which might be materially reduced, and in some instances eliminated, through controlled water management practices. Surface water accumulations result during periods of excess precipitation, when water moving over the land or precipitation falling on the surface exceed the intake and permeability rates of the soils. Flooding by overbank streamflow

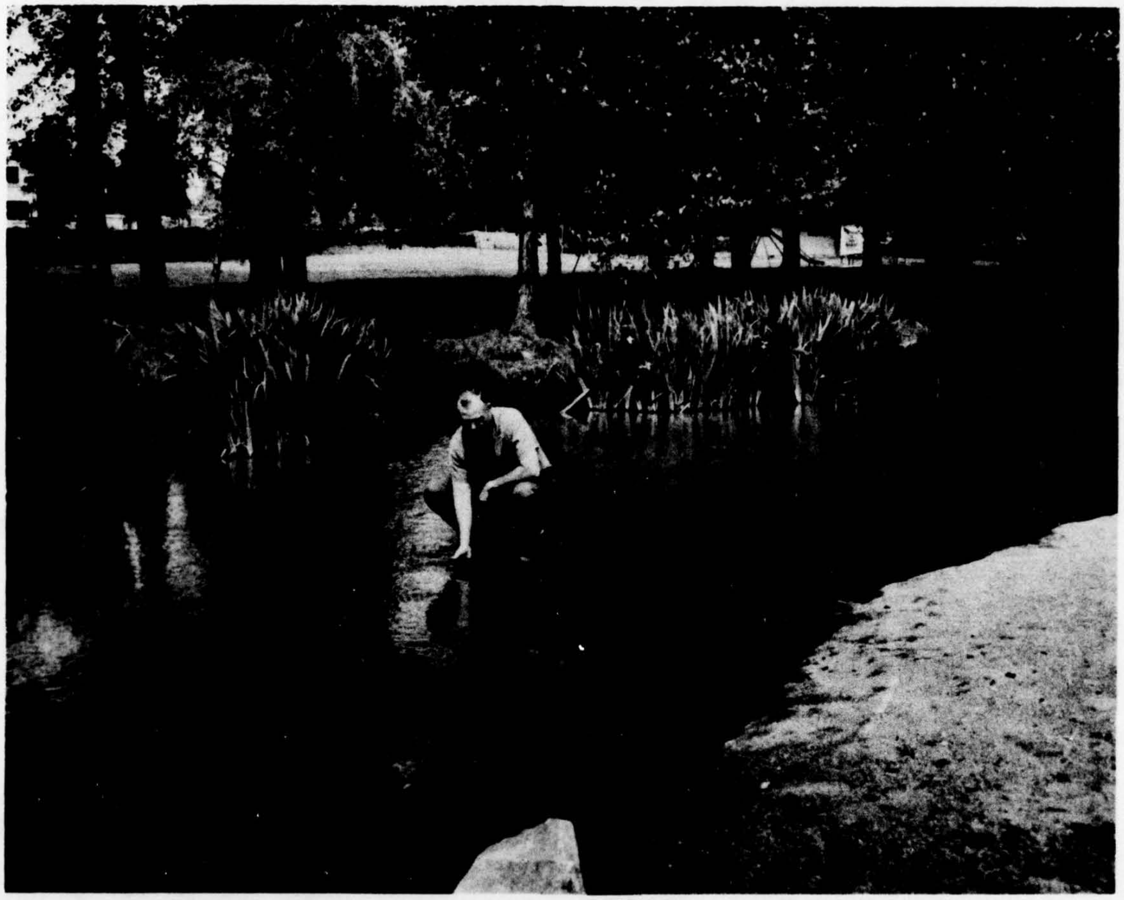


PHOTO 2-17. This stream was filled with sediment from the erosion shown in Photographs 2-15 and 2-16. The stream at this point was 18-24 inches deep just a few weeks before. In this picture, the water is about an inch deep and floods over the bank. Fish, wildlife, and the general public have suffered a loss. (SCS)

inundates rapidly permeable and slowly permeable bottom land soils and, by saturation, causes soil drainage problems regardless of native permeability rates.

Water runoff from urban and rural nonagricultural development is accelerated as paved areas, rooftops, and soil compaction limit the areas of soils that will permit the rapid infiltration of water. The flow into stream channels thus tends to exceed channel conveyance capacities, resulting in higher flood levels than those which occurred while the land was under forest and grass cover. Likewise, low basins within urban development areas are subjected to flooding and ponding during periods of excess precipitation. This results in flooded streets and basements and other property damages. Saturated soils in urban areas decrease soil stability and create a variety of problems.

Exclusive of national park and national forest lands, 2,036,900 acres, or 43 percent of the Puget Sound Area, have conditions of excess water during the wet season which affect production of food and fiber or other developed uses of the land. There are 477,500 acres of alluvial lands subject to inundation by overbank flooding of streams, and an additional 269,500 acres subject to ponding during periods of excess precipitation. About 1,289,900 acres are sloping lands and upland soils with restrictive horizons subject to seeps in excavations and road cuts because of perched water conditions. Additional

lands with similar problems occur in the national forests and national parks but these areas have not been included in a soil survey.

Not all of this land "needs" to be drained. Only when the land is required for productive purposes, or for construction where excess water interferes with a beneficial purpose or causes damage, is a need established. Some land requires drainage now, and additional amounts and degrees will be required as the demand for land increases. See Table 2-12, Future needs for watershed management, for estimated drainage needs by time periods.

### Subsurface Drainage Conditions

It is important to consider subsurface drainage conditions by the source of the excess ground water and the way it moves into and through the problem area. Identifying subsurface conditions is necessary for the treatment of the more complex drainage problems because it also indicates the kind of drainage system needed. Reconnaissance and preliminary surveys are carried out to obtain the needed information on ground water occurrence and other site conditions.

In valley bottoms and on wide benchlands the free ground water saturates the sediments down to the first impervious barrier. Typically, the water table slopes gently down the valley. This large, very slow-moving body of ground water is fed by surface streams or other waters percolating into watershed lands, and by infiltrating rainfall, irrigation losses, or surface runoff on the valley floor itself. Eventually, the ground water discharges through seepage at streambanks or at the ground surface in low areas, or it escapes through aquifers at the lower end of the valley or benchland. The height of the water table fluctuates with the seasonal variations of the ground water increment. The general slope of the water table varies only slightly in response to these changes in inflow.

Relief drains are sometimes installed to lower the water table in such areas unless soil permeability is too slow, the ground water slope too nearly level, or the pervious sediments too deep for efficient interception. Interception drains are sometimes useful at the margins of soil bodies where the soil permeability or depth to an impervious barrier changes, or in areas where ground water slope changes rapidly. Pumps may be required to discharge drainage water from areas of low elevation, and dikes or other protective measures may be required to protect localized areas from waters originating outside the improved zone.

Table 2-7 shows typical physical properties of soils.

In many medium-textured soils, the pore spaces total about 40 percent of the total volume. About 25 percent of the total volume is capillary water and the remaining 15 percent is air or water. In such a soil, gravitational water would be 15 percent by volume if the soil were saturated. Other soils vary from over 20 percent to 5 percent or less in volume of gravitational water at saturation. Gravels will hold even more gravitational water, depending upon the size and gradation of the gravel.

**TABLE 2-7. Typical physical drainage properties of soil textures[1]**

| Soil Type | Dry Weight of Soil: Lbs. Per cu. ft. | Porosity: Percent | Porosity: Inches of Water in 1 Foot of Saturated Soil | Maximum Field Capacity Equals Maximum Capillary Capacity: Percent Volume | Percent Weight | In./Ft. of Depth | Gravitational Water Per Foot of Depth: Inches Removable by Drainage |
|---|---|---|---|---|---|---|---|
| Sand | 105 | 30.5 | 3.7 | 8.23 | 4.9 | 1.0 | 2.7 |
| Sandy loam | 100 | 34.0 | 4.1 | 17.00 | 10.6 | 2.0 | 2.1 |
| Sandy loam | 95 | 37.5 | 4.5 | 24.13 | 15.9 | 2.9 | 1.6 |
| Sandy silt loam | 90 | 41.0 | 4.9 | 30.60 | 21.2 | 3.7 | 1.2 |
| Silt loam | 85 | 44.5 | 5.4 | 36.42 | 26.8 | 4.4 | 1.0 |
| Silt loam | 80 | 48.0 | 5.8 | 41.60 | 32.7 | 5.0 | 0.8 |
| Clay loam | 75 | 51.5 | 6.2 | 46.13 | 38.5 | 5.5 | 0.7 |
| Clay | 70 | 55.0 | 6.6 | 50.00 | 44.6 | 6.0 | 0.6 |

[1] After Pickles, Drainage and Flood Control Engineering, McGraw-Hill. 1941.

## Internal Drainage Systems and the Release of Gravitational Water

Drainage systems provide a new or improved release for the water stored as gravitational water in the soil. The volume of this gravitational water in a saturated soil that is removable by drainage varies from something over one-half inch per foot of soil in clay to in excess of two and one-half inches per foot of depth in a sandy soil. Table 2-7 "Typical Physical Properties of Soil Textures" indicates the amount of gravitational water available per foot of depth for the various types of soil from sand to clay.

Gravitational water normally is not used by vegetation but is released slowly and to a large extent forms the base flow of streams or percolates to the groundwater regimen. Gravitational water and ponded surface water are released more rapidly when subsurface drainage systems are installed.

The pore volume in the soil released by the removal of drainage water is available for the temporary storage of rainfall from future storms. An example of this available storage would be saturated silt loam soil which might contain one inch of water per foot of depth (Table 2-7). Assuming subsurface drainage effective to six feet in depth is installed, then there are six inches of removable water in the soil profile. A square mile of wet land containing silt loam soils to a depth of six feet would contain a reservoir of 320 acre-feet of water, which would be removed by the drainage system. The land would thus be returned to a condition to receive and temporarily store more precipitation.

Most drainage systems installed or proposed in the Puget Sound Area are beneficial for flood control and stream regulation because most outflows of drainage improvements are relatively slow or completely blocked at higher flows of the principal streams. This is especially true when the outlet is controlled by a tide or floodgate structure. Pump outlets will occasionally add to flood peaks but it is rare that pump outlets are of sufficient capacity to materially affect the peak flow of a stream. Flood storage provided within the soil profile and by drainage of low-lying areas frequently provides considerable benefit in reducing peak flows from a watershed.

The quality of subsurface drainage water is generally good to excellent. A minimum amount of erosion is caused by these relatively slow flows and seldom is there contamination by sediment. Outflows from subsurface drainage fields have been filtered through several feet of soil and most impurities have been filtered out. Occasional areas containing peat soils may cause a slight discoloration but the water is generally of good quality for most purposes.

The location of the outlet of a drainage system determines if the water collected by drainage can be used beneficially. Many outlets in the Puget Sound Area discharge directly into the Sound or estuarial zones. A majority of the drainage systems are in the lower reaches; some are in the middle reaches of the rivers; while relatively few are in the higher elevations of the watersheds. The usefulness of the drainage outflow for other purposes depends on local conditions.

There is no shortcut method for solving all drainage problems. Some situations and locations have obvious tested solutions. In many cases, however, the complexities of topography, soils, hydraulic gradients, and water sources combine to create unique conditions that must be investigated in detail. Several drainage factors deserve special mention. The investigation of each factor will normally include reconnaissance, preliminary and evaluation stages, in order to rapidly and economically eliminate possible alternatives and converge on the most advantageous solution.

**Surface Investigations**—will generally define surface slopes, extent of problem area, and location of potential outlets. This investigation will also evaluate flood hazard and other watershed hazards which may materially affect the behavior of surface and subsurface water and sediment movement. The objectives of drainage, and the degree of drainage required should be fully considered during this part of the work.

**Ground Water Investigations**—are generally conducted by the temporary installation of observation wells to determine the free ground water table, and piezometers to register the hydrostatic pressure at various depths. These observations are used to determine the extent and pattern of the problem, and are used in conjunction with surface observation of vegetation to provide data on the position and fluctuation of the ground water table. The source of the water to be removed is of considerable importance in determining remedial measures. These waters may, in some cases, be derived mainly by precipitation on the area to be treated; in other instances, because of soil character or topography, water may be imported from outside the site by surface flow or seepage, and in some cases through artesian pressure.

**Soil Investigations**—are required to determine the location, extent, relationship, and physical characteristics of the various underlying horizons. It is necessary to determine the thickness of the various strata, their hydraulic conductivity, and whether they are continuous, independent, or overlapping. The soil investigation, correlated with the ground water investigation, should define the source, movement, and storage of water in the soil in quantitative terms. The amount of detail varies with the site and with various objectives but should be competent to indicate underground soil changes. Soil changes typical of the Area include clay barriers that are relatively common in old lake areas and act as underground dams to cause a build-up of saturated soil; breaks in grade in conjunction with a soil change commonly occur in benched areas and sometimes cause hydrostatic pressure. Similarly, soil relations caused by old filled-in and meandering stream channels, as well as situations derived from buried alluvial fans, create highly permeable, wedge-shaped strata that may be covered by heavier soils. Once the subsurface condition is known, and the source and movement of soil water discovered, the drains can be located with effectiveness.

The conditions found by investigation determine whether subsurface intercepting drains, random lines to concentrated seepage areas, mole drains, pattern drains to depress water table conditions, or relief drains to dissipate artesian or hydrostatic effects are necessary. The investigations will also determine the depth at which the drains must be placed to be effective.

## Collection and Conveyance of Drainage Water

The configuration, depth, and capacity of the system for extracting unwanted water from the soil, as well as economic factors and objectives of the improvement, often dictate whether open canal-type drains or covered underground conduits are indicated. The two types of collecting systems are not entirely interchangeable despite usual economic criteria.

**Surface Channels**—may be shallow—from two to five feet deep—to serve in collecting and transporting accumulations of ponded water, water derived mainly from local precipitation, or water under conditions where soil characteristics or other factors cause subsurface drains to be ineffective. Such drains are also used where the volume of flow precludes the use of pipe. Deep channels may be 5-20 feet or more in depth and serve often as main outlet channels for the drainage system, outlets for tile or surface collecting drains, and temporary storage for the collected drainage flow.

A special case of shallow channels for collection of water may be the use of graded hillside terraces and outlet systems to collect water from long steep slopes, and to convey the collected water supply to lower areas; or, in some cases, to dissipate the water by spreading it in areas of high soil permeability for ground water recharge. Terrace-type collecting systems are not widely used in the Area at the present time but may prove useful as intermediate slopes are cleared of timber and used for cropland or housing. In the case of housing developments, the terraces in some cases may be paved and used for driveways and streets, thus accommodating two purposes.

**Covered Drains**—are often of concrete or clay tile and sometimes of perforated plastic or composition materials, or galvanized metal. The material used should be compatible with the service required, and selected after consideration of any corrosive character of the soil (see Exhibit 1, Table 14). The depth of the drain is related to the outlet condition, topography, and the position of the water-bearing strata. Drain lines should be laid on an accurate grade, adequately supported, protected from excessive surface loads, and installed with consideration for ease of maintenance and repair. Water must enter such drains through openings provided in the drain line, either at joints between short tiles or through perforations in continuous pipe. In most soils it is necessary to surround the drain with a filter or envelope of pervious granular material graded to allow water to enter the tile but prevent erosion of the base soil and damage to the installation. The graded filter should be designed on the basis of a sieve analysis of the soil in which the drain is placed and be of adequate thickness to provide effective protection against erosion of the soil throughout the economic life of the drain.

**Outlets for Drainage**—typically consist of a reach of pipe or canal terminating at the actual point of discharge. While such conduits may sometimes be underground pipe, the quantities of water to be conveyed under peak service conditions usually exceed the economic capacity of the pipe. Discharge is usually into natural streams or into tidal areas of Puget Sound.

The nature of such outlet channels often requires that they cross portions of the natural flood plain of streams where the fine alluvial soils typically

present may require careful construction procedures and protective measures for stability. In addition, such channels often require protection from flooding and sediment damage caused by natural streamflow.

Where elevation and topography permit, discharge into the stream may be by gravity. Many locations, however, must depend on pumping discharge, either entirely, or at times under some conditions of operation. Where discharge is by gravity, the structure usually is provided with a floodgate to prevent reverse flow of water into the channel from stream freshets or tidal variations.

Pumps for drainage discharge are, typically, large-capacity, low-head pumps powered by electric motors or internal conbustion engines. Because of the wide range of flows to be discharged, such pumping plants usually will consist of several pumps arranged so that discharge can be adjusted to the flow. Special attention to design features contributing to reliability of operation under varied conditions is desirable.

## AGRICULTURAL DRAINAGE

It is well recognized that plants need both air and moisture in their root zones. Water in the soil in excess of field capacity restricts aeration of the soil and inhibits plant growth. Where conditions of topography, ground water table, or impermeable subsoil inhibit the natural movement of gravitational water from the root zone, artificial subsurface drainage is an essential practice if a high level of productivity is to be developed and maintained. Ponded water can be removed from the surface to reduce the amount of water entering the soil but only natural or artificial subsurface drainage can lower a water table to provide an aerated root zone.

Many drainage systems have been and currently are being installed for agricultural water management. The better agricultural lands in the Puget Sound Area are located along alluvial valleys and in other locations subject to prolonged conditions of flooding and seepage. Drainage improvements consist of water collection systems and outlets to suitable public waters by gravity flow or by pumping where required.

Drainage of croplands is the removal of excess surface water and excess soil water to permit cultivation and efficient harvest operations, improve crop quality, and increase yields. Many acres of cropland in the Area have been and are being improved by the installation of some degree of drainage. Acreages with fully effective drainage to achieve optimum conditions for crop growth are found in some of the more developed areas but the percentage of lands with fully adequate drainage is relatively small. There is no readily available method for estimating the number of drainage systems installed or the number of acres drained during previous years in the Area, as no records were kept for early efforts. Much of the effort at present is directed toward intensification and improvement of efficiency of drainage on acreages previously partly improved.

Agricultural drainage is primarily installed by individual landowners who are induced to make the investment in anticipation of future increased financial returns from the land. Drainage is one of several alternative improvements or measures capable of providing increased production, either alone or in combination with other improvements. The agricultural benefits from drainage depend on the crop or crops being raised and upon the quality and state of other management on the land. The nature of drainage benefits to agriculture is discussed in Appendix V, Water-Related Land Resources, in Chapter 2, Agriculture. For the usual Puget Sound conditions, agricultural drainage will provide an average net benefit of $16.10 per acre, exclusive of outlet costs that vary widely with local conditions. (See Exhibit 6 in Appendix V, Chapter 2, Agriculture).

Measures to provide additional drainage of cropland are being installed annually and are expected to keep pace with demands for farm production. New cropland is not expected to be brought into production through installation of drainage; only presently used cropland is expected to be improved. Much of the large amount of drainage

**PHOTO 2-18. A good drainage system adds to the efficiency and productivity of cropland. (SCS)**

expected to be installed in future years is for improvement of partially drained lands, and for extending drainage in areas where difficult outlet conditions, hazards of flooding, or low levels of management have prevented previous full improvement. This is based in part on an assumption that increasing demand for farm products derived from a diminishing area devoted to farming will induce improvements in management and innovations in technology that will cause average unit production in 2020 to at least equal the unit production now experienced by the highest decile of producers in the Area.

Many areas needing drainage also require flood prevention measures to make drainage fully effective, or to make added investments in farm production measures more secure. Often, wet areas are located where outlet conditions are difficult or require group action. Such locations require agreement among landowners for community drainage outlets and often present troublesome and expensive rights-of-way problems.

About 540,100 acres of the 591,500 acres presently in cropland have a wetness problem that limits production to some degree.

## NONAGRICULTURAL DRAINAGE

Drainage and water control measures are used to stabilize soils for streets, highways, and low buildings. Streets and highways built on flood plains or terrace and upland basins subject to flooding by ponding during periods of excess precipitation, require fills above flood levels. Terrace and upland soils which are underlain by restrictive soil layers require water control measures in critical seep areas.

Industrial and urban building foundations require water control measures to stabilize soils which have moderate to high shrink-swell potentials, or to stabilize laminated soils, such as the Kitsap series, against severe slide potentials on sloping areas. These specialized applications of drainage improvements should be designed by experienced engineers after specific site investigations.

Drainage principles are applicable to many nonagricultural uses. Several aspects of such drainage are considered here: (1) drainage for municipal and industrial developments; (2) drainage for transportation systems; (3) drainage of recreational areas and for vector control; and (4) water quality improvement through drainage.

PHOTO 2-19. Soil slump on Kitsap-like soils two miles southwest of Renton in King County. Note vertical shear characteristic of slumping. (SCS)

### Drainage for Municipal and Industrial Developments

Each municipal or urban area has several basic drainage problems which vary in complexity with the size and location of the community. Provision must be made for the collection and disposal of municipal and industrial wastes on a day-to-day basis, while at the same time providing for the storm occasions which may overtax disposal and drainage facilities.

Sanitary sewage disposal systems collect, convey, and treat waste materials before discharge. The character and volume of sewage flow depends on whether the area served is residential, industrial, or mixed. The volume can be estimated from the number of inhabitants or from consideration of service connections. The chief distinguishing feature is the treatment requirement before disposal of effluent. Sanitary and industrial sewerage disposal is considered mainly in Appendix XIII, Water Quality Control, although the use of soil as a septic tank filter area is considered in the following pages.

Storm sewer drainage systems usually consist of relatively small collecting conduits and larger trunk lines to collect and dispose of accumulations of storm and other drainage waters. The water frequently enters conduits through gratings set in street curbs and from individual connections. Some municipalities collect and dispose of storm runoff through sanitary sewers. Where this is done, heavy storm runoff increases the cost of treatment and overloads treatment plants causing discharge of untreated effluent. Often the sanitary conveyance system is overloaded

during storms, causing a backup of sewage in unlikely locations, with considerable damage to property as well as hazard to the public health.

The typical pipe conduit storm sewer system cannot usually be economically constructed with sufficient capacity to carry the water from large storms. Furthermore, the usual pipe system is subject to becoming inoperative because of accumulations of trash at curb inlet gratings during heavy flows. However, these systems perform service in collecting runoff from storms of frequent occurrence. In this way, they prevent ponding on streets, contribute to vehicle and pedestrian safety, and convenience, and eliminate considerable damage to property. Some years ago such systems were typically constructed on the basis of storm recurrence frequencies of two-to-five years. The present trend is to design for the 10-25 year, or even less frequent, storm occurrence. The design should be judged on the basis of the local situation; however, this more liberal design frequently has the effect of considerably increasing installation costs without greatly decreasing the tendency toward blockage of intake openings at critical times. There is considerable justification for believing that in many instances the increased cost of the larger conduit may not be economically justified by the incremental benefits secured. The most serious aspect, however, is that the more elaborate pipe system may lull the public into neglecting the emergency facilities required for the large, infrequent storms.

**Drainage Following Large Storms**—Regardless of the construction of the facilities described above, a storm occasion will occur at infrequent intervals when the storm sewer systems are inoperable or inadequate to handle the runoff. The path that excess water follows under such conditions is often disregarded in planning urban drainage. Developers locate expensive and vulnerable improvements in such a way as to encroach into the flood path. Failure to recognize the importance of providing for the conveyance and disposal of water from the larger storm results in significant floodwater damage. The larger, or emergency, water disposal system should be a planned part of each development and should take advantage of low swales or other topographic detail to provide an adequate and unobstructed open channel. Often the emergency channel can be maintained in lawns or playgrounds and made a part of esthetically desirable open space, or, alternatively, it may be possible to provide adequate capacity in natural stream channels. In other cases, capacity can be provided in carefully graded street and curb reaches.

**Collection and Conveyance of Urban Flows**—Some municipalities seem to provide facilities for collecting and conveying flood and drainage waters within their boundaries but release the flow as rapidly as possible into rural drainage facilities, roadside ditches, and streams. The outlying portions of these facilities are often inadequate, unless specifically planned, constructed, and maintained to accommodate the high peak flows from developed areas. Difficulties are usually the result of inadequate foresight in planning and constructing comprehensive facilities for long-range utility. The properly planned system collects the water near the source of origin, and conveys the water safely and economically to a point where it is discharged into public waters without undue pollution or other ill effects. The hindrances to such comprehensive planning frequently are fragmented government responsibility, lack of finances, and lack of public understanding of the problem. Such planning must go far beyond the simple design of a conduit to convey the flow because it includes the prior comprehensive planning of street drainage systems and may require ordinances for zoning and construction as well as projection of the needs of the system for many years into the future. Many of these costs are difficult for the general public to accept. In a new community, many of the large costs occur while the population is small, thus adding to the burden.

Land fill at times adds to drainage problems. A common procedure for an owner developing property in low areas is to haul land fill onto his property, thus raising the ground level to avoid ponding against his buildings. The result of this practice is to force excess water onto adjacent property, transferring a part of the cost, and beginning a source of wasteful and unplanned competition for temporary protection without solving the basic problem. Uncontrolled urban developments tend to sprawl over wide areas, thus wasting land resources and creating many drainage problems. Many such developments are unplanned and usually under-financed. Often communities enter into competition to obtain industries that will, hopefully, bear part of the cost of the development and concessions sometimes may be offered to potential industrial developers that are unwise or unwarranted.

Urban and industrial developments sometimes

form within diking districts, drainage districts, and similar entities originally created to provide farm land drainage and taxed for this purpose. Urban and industrial developments create a need far beyond that contemplated or financed at the time the district was formed. The urban developments contain relatively high damageable values and need a greater degree of protection against ephemeral waters. At the same time, concentrations of urban and industrial wastes and storm waters overload existing drains, thereby aggravating drainage problems over considerable areas where urban developments contribute little or no financial assistance to the district. In other areas, storm drainage and pollutants flow beyond urban boundaries, mingle with drainage flows from lands outside organized districts, and flow into districts which must handle greater volumes than originally conceived.

The studies and the corrections must be dynamic enough so that they can follow trends of population concentration and changes in land use. They should be well enough supported and financed so that long-range planning and guidelines can be established to provide methods for securing the necessary rights-of-way, for installing the means of conveying the water, and for any effluent treatment required. They should have the means to evaluate the feasibility and the desirability of future projects from the standpoint of the public interest.

Financing must be provided. Sponsors must provide for the extended and long-range comprehensive planning required for adequate drainage. Under Public Law 566, agreements as to responsibility and financing are usually contained in work plan agreements.

**Soil as a Disposal Area**—Many suburban areas and small municipalities depend on septic tanks and soil absorption for disposal of wastes. It is estimated by Bendixen[1] that 25 percent of the nation's population depends on sanitary waste disposal through soil absorption. This large percentage stems mainly from post-war building trends that resulted in suburban subdivision development beyond sewage disposal facilities of the cities. The percentage in the Puget Sound Area is estimated to approximate the national average.

Many septic tanks do not operate satisfactorily. McGaughey and Winneberger[2] report that as many as one-third of the septic tanks in a single subdivision may fail during the first three or four years of use. Disposal system failures represent a large economic loss and constitute a threat to public health. Septic tank systems are not considered generally suitable as a permanent means of sewage disposal for residential or commercial areas or areas having difficult soil problems.

The septic tank ordinarily is a watertight tank, usually buried in the ground, with an inlet and outlet. The function of the tank is to receive and retain wastes for digestion so that the resulting effluent may be percolated into the soil more readily. Effluent from the tank is discharged into the soil, usually by a percolation field. Biological decomposition of solids under septic (anaerobic) conditions takes place in the tank. The main function of the septic decomposition is to liquify the wastes. Filtration is performed outside the tank as effluent is percolated into the soil. Effluent from the tank, ideally, is distributed evenly over a percolation field where it is further acted upon by micro-organisms under aerobic conditions and percolated into the soil.

The function of the system is disrupted if any one of these operations fails to take place efficiently. Failure may be due to poor design or construction, inadequate capacity of the tank or percolation field, or the failure to fully consider soil characteristics in the selection or design of the percolation field. Failure of a system is usually progressive and a malfunction, once it begins, may lead to a complete operational breakdown.

If a septic tank is of inadequate size, is not operating properly for any reason, or is not maintained, digestion will not be completed and sludge will be discharged into the percolation field. Sludge may rapidly clog a filter bed. Septic tank sludge must be removed from the tank periodically, perhaps every three to five years, depending on the use and size of the tank.

Poor installation of the distribution system may overload part, and inadequately utilize the remainder of the percolation field, resulting in poor operation. Improper operation also results if the infiltration area is too small, or if the water table is too high. Where the effluent is not absorbed rapidly enough, it will back up in drains or rise to the surface of the ground

[1] Bendixen, T.W., Field Percolation Tests for Sanitary Engineering Application, Tech. Publ. 322, American Society for Testing Materials, Philadelphia, Pa. 1962.

[2] McGaughey and Winneberger, Summary Report on Causes and Prevention of Failure of Septic Tank Percolation Systems. 1963.

over the infiltration area. If the effluent drains through the soil too rapidly, it may contaminate nearby wells and surface water supplies. Many failures are the result of soil factors, i.e., the failure to fully consider soil characteristics in the disposal field design.

Consideration of soil factors usually is based on an estimate of soil permeability. Estimates of permeability may begin with spot tests for permeability or by inspection. These tests often lead to errors, either because the tests are improperly made or, more often, because the permeability of the soil bed for effluent may change with time under conditions of use.

Cain and Beatty[1] point out the usefulness of isolated percolation tests is limited in situations where there may be a fluctuating water table, or where ground is frozen or abnormally dry at the time of the test. Tests are of little value if improperly made or where the ground is subsequently disturbed during construction. Many factors affect the clogging of the soil other than its initial permeability. Soil clogging is caused in part by suspended solids or colloidal material in the effluent. Serious consideration should be given to all design features that will reduce the discharge of solids with the effluent. Good design of the system, careful construction, and systematic maintenance are very important factors in successful operation.

Soil permeability depends on several factors of which structure is the most important single characteristic. O'Neal[2] shows that the relationship of principal axes of aggregates, the presence of fractures, form of aggregation, presence of pores, and the appearance of mottling are important considerations in addition to soil texture. Changes in permeability, therefore, may result from mechanical disturbances of the soil during construction, clogging of the soil interstices, or breakdown of the soil aggregation by chemical or biological means.

Chemical and biological effects of the effluent may serve to break down the soil structure or to precipitate iron in a zone around the tile so as to reduce permeability. Since the most troublesome clogging occurs under anaerobic conditions, care should be used to keep the filter bed in an aerated condition as much of the time as possible. When soil clogging once starts, it may be self-perpetuating since the changes begun may assist in maintaining the anaerobic condition. The presence of a high or fluctuating water table, also, can contribute greatly to clogging conditions for the same reason. The best soil for filtering is one that will accept the effluent at a reasonably rapid rate; one that can maintain aerobic conditions during the infiltration process; and one that has ample absorption surface. The permeability characteristics under conditions of use should allow adequate time for microbial decomposition.

[1] Cain & Beatty, Disposal of Septic Tank Effluent in Soils, Journal of Soil and Water Conservation, May 1965.

[2] O'Neal, A.M., Some Characteristics Significant in Evaluating Permeability, Soil Science 67, 403-409, 1949.

## Water Quality Improvement Through Drainage

**Ground Water Contamination**—The possibility that effluent from septic tanks may contaminate ground water has been expressed frequently. The information on this subject is not very definite. When septic tanks were widely scattered, the problem was of less consequence. With increasing population and the use of septic tanks in crowded conditions, awareness of the potential pollution problem has increased. The size and number of such installations per acre is an important consideration and varies with location and soil quality.

Some of the concern for the problems involved has to do with the lack of adequate control over the installation and maintenance of septic tank systems, as well as site selection. To be adequate, the control should involve not only the investigation and the design in the conditions under which septic tanks are permitted, but also strict control of construction and subsequent maintenance.

An especially useful tool to assist in planning septic tank areas is the soil survey report. With the soils map and related interpretive information available, it is possible to delineate areas where septic tanks cannot be used successfully. These areas include poorly drained soils, and flood plains. There are areas where the use of a septic tank is limited or where special design features will be required. Artificial drainage may be used in some cases to improve drainage for disposal fields where high water table is a limiting factor. Other areas include slowly permeable soils and highly variable soils, and may include extremely permeable soils where ground water contamination is expected to become a problem. (See Exhibit 1, Table 14).

The soils map is useful for describing the soil conditions over relatively large areas; however, small inclusions of different soils may not be shown on the

form within diking districts, drainage districts, and similar entities originally created to provide farm land drainage and taxed for this purpose. Urban and industrial developments create a need far beyond that contemplated or financed at the time the district was formed. [illegible] urban developments contain relatively high damageable values and need a greater degree of protection against ephemeral waters. At the same time, concentrations of urban and industrial wastes and storm waters overload existing drains, thereby aggravating drainage problems over considerable areas where urban developments contribute little or no financial assistance to the district. In other areas, storm drainage and pollutants flow beyond urban boundaries, mingle with drainage flows from lands outside organized districts, and flow into districts which must handle greater volumes than originally conceived.

The studies and the corrections must be dynamic enough so that they can follow trends of population concentration and changes in land use. They should be well enough supported and financed so that long-range planning and guidelines can be established to provide methods for securing the necessary rights-of-way, for installing the means of conveying the water, and for any effluent treatment required. They should have the means to evaluate the feasibility and the desirability of future projects from the standpoint of the public interest.

Financing must be provided. Sponsors must provide for the extended and long-range comprehensive planning required for adequate drainage. Under Public Law 566, agreements as to responsibility and financing are usually contained in work plan agreements.

**Soil as a Disposal Area**–Many suburban areas and small municipalities depend on septic tanks and soil absorption for disposal of wastes. It is estimated by Bendixen[1] that 25 percent of the nation's population depends on sanitary waste disposal through soil absorption. This large percentage stems mainly from post-war building trends that resulted in suburban subdivision development beyond sewage disposal facilities of the cities. The percentage in the Puget Sound Area is estimated to approximate the national average.

Many septic tanks do not operate satisfactorily. McGaughey and Winneberger[2] report that as many as one-third of the septic tanks in a single subdivision may fail during the first three or four years of use. Disposal system failures represent a large economic loss and constitute a threat to public health. Septic tank systems are not considered generally suitable as a permanent means of sewage disposal for residential or commercial areas or areas having difficult soil problems.

The septic tank ordinarily is a watertight tank, usually buried in the ground, with an inlet and outlet. The function of the tank is to receive and retain wastes for digestion so that the resulting effluent may be percolated into the soil more readily. Effluent from the tank is discharged into the soil, usually by a percolation field. Biological decomposition of solids under septic (anaerobic) conditions takes place in the tank. The main function of the septic decomposition is to liquify the wastes. Filtration is performed outside the tank as effluent is percolated into the soil. Effluent from the tank, ideally, is distributed evenly over a percolation field where it is further acted upon by micro-organisms under aerobic conditions and percolated into the soil.

The function of the system is disrupted if any one of these operations fails to take place efficiently. Failure may be due to poor design or construction, inadequate capacity of the tank or percolation field, or the failure to fully consider soil characteristics in the selection or design of the percolation field. Failure of a system is usually progressive and a malfunction, once it begins, may lead to a complete operational breakdown.

If a septic tank is of inadequate size, is not operating properly for any reason, or is not maintained, digestion will not be completed and sludge will be discharged into the percolation field. Sludge may rapidly clog a filter bed. Septic tank sludge must be removed from the tank periodically, perhaps every three to five years, depending on the use and size of the tank.

Poor installation of the distribution system may overload part, and inadequately utilize the remainder of the percolation field, resulting in poor operation. Improper operation also results if the infiltration area is too small, or if the water table is too high. Where the effluent is not absorbed rapidly enough, it will back up in drains or rise to the surface of the ground

[1] Bendixen, T.W., Field Percolation Tests for Sanitary Engineering Application, Tech. Publ. 322, American Society for Testing Materials, Philadelphia, Pa. 1962.

[2] McGaughey and Winneberger, Summary Report on Causes and Prevention of Failure of Septic Tank Percolation Systems. 1963.

map. It is therefore advisable to make an onsite evaluation where improvements are planned. Such an investigation can best be performed by personnel trained in making interpretations based on observable morphological characteristics of the soil, and in comparing the specific soil with similar morphology that has been studied elsewhere. Use of the map can also contribute to sound planning, including the identification of zones where septic tanks may be successful, as well as assisting in delineation of areas where use of the tanks is not in the public interest. As population densities increase in any area, septic tanks should be replaced with community disposal systems of adequate design.

**Relationship of Drainage to Pollution from Productive Lands**—All life processes, and all activities of industry, municipalities, and agriculture, produce by-products that consist of materials or energy surplus to the needs of the producer at a particular time or place. The term "producer" refers here to the agent creating the by-product. Some of these by-products are obviously of value to producers who convert and re-use them immediately as inputs in new processes. Other by-products are of such insignificant usefulness the producer is induced to discard them as quickly and cheaply as possible. By-products disposed of in this manner are "waste" products. Waste products may be solids, liquids, gases, or energy components that are discharged into the atmosphere, the land, or the water for disposal.

In nature, wastes derived from animals and plants quickly become substrates for the continued growth of plants and animals and disturbance to the environment is minimal. The activities of man often cause great concentrations of many kinds of waste that cannot be quickly and easily assimilated into the environment by natural processes. Problems caused by disturbance to the environment before and during the assimilation is called pollution.

The human producer thus may have two alternatives: first, he may convert the by-product into something useful and re-use it, or second, he may discard the waste into some element of the environment for natural processes to reduce. The use of manure for fertilizer, and the manufacture of sulphuric acid out of smelter wastes are examples of controlled conversion and re-use. The burning of garbage, the burying of refuse in the earth, or the discharge of treated or untreated sewage into a river are examples of relinquishment by man of his control over the wastes in favor of natural forces which serve eventually to assimilate the substance into the environment.

The conversion and re-use of waste is, of course, the most attractive alternative means of eliminating the unwanted by-product. It is most attractive because the process remains under control, which should make it possible to eliminate most of the nuisances caused by disturbances in the environment. Unfortunately, many of the known methods of conversion and re-use are not financially profitable, and some forms of waste from modern enterprises seemingly defy practical methods of conversion. The re-use or disposal of waste materials into the environment seems likely to become one of the major problems of the future. The relative amount of re-use of by-products will likely increase as time goes on, either for economic reasons or because of increased restrictions on incineration and other common methods of waste disposal, but it appears unlikely it will be possible to completely eliminate the disposal of at least some forms of waste into the environment.

The main interest here is the pollution of water and related lands by wastes. Pollution occurs when the quality of water for some purpose is materially lowered by such wastes. The increase in the number of specific uses of water multiplies the ways in which the quality may be impaired. The Senate Select Committee on National Water Resources, in Committee Print No. 9, specifies eight general categories of water pollutants as follows: (1) sediments, (2) sewage and other oxygen-demanding materials, (3) plant nutrients, (4) infectious agents, (5) organic chemical exotics, (6) salt and mineral substances, (7) radioactive substances, and (8) heat.

Agricultural and open uses of land share with manufacturing enterprises and municipalities in discharging unwanted substances into the water supply, although the discharge of radioactive substances or generated heat is presently very small. The probable future use of atomic or fossil-fuels for various purposes will produce significant localized problems of heat pollution that will require intensive study for suppression or mitigation. Some heating of streams during periods of low flow is occasionally caused by logging along small streams, thus exposing the Area to greater effects of solar heat. Potential agricultural pollutants commonly originate, or are spread, on the land surface and are carried to streams and lakes mainly by overland flow. As the demand for high-quality water increases, greater conservation efforts will be needed to prevent pollution of water from

overland runoff. Drainage practices that encourage infiltration and disposal of subsurface water in lieu of surface runoff are important in preventing pollution.

**Sediments**–are one of the main pollutants of surface waters. Sediments from erosion fill stream channels, increase water supply treatment required, inhibit oxidation of organic pollutants, and reduce fish and shellfish populations and habitat. While croplands and forest produce considerable sediment, a major sediment source lies with urban activities also. Suburban and industrial development frequently removes all vegetation from large areas of land, exposing them to erosion. Erosion sediments not only cause damage to the stream regimen and to property in the overflow area, but they also serve to carry a large portion of other pollutant materials derived from the land.

**Organic Wastes**–Sewage; animal wastes and effluent from dairies; wastes from canneries; logging debris; and wastes from certain timber-processing industries and similar processing plants, impair the quality of water, mainly through the biochemical demand on dissolved oxygen (BOD) required to decompose the organic matter. Fortunately, organic pollutants may be largely oxidized and removed by the passage of water through the soil, and this process is closely connected with drainage practices.

Untreated municipal sewage has a BOD in the range of 100 to 400 parts per million. Waste from animal feedlots may have a BOD ranging from 100 to 1,500 parts per million. Waste from vegetable canneries may vary from 100 to 10,000 parts per million, and juice from pea vine ensilage may run as high as 75,000 parts per million.[1]

In studies at the National Institute of Health, the following animal equivalents to human sewage production were determined: man, 1; cow, 16.4; pig, 1.9; sheep, 2.45; chicken, 0.014. These data could indicate that a feedlot handling 1,000 head of cattle would have the waste disposal problem of a small city. Despite these high rates of potential organic pollution, it is possible in most cases to dispose of this material without stream deterioration. Studies made at Pennsylvania State University[2] confirm that one of the best and most economical ways to purify polluted water is to let it percolate through the soil; thus areas where animals are concentrated should be located on well-chosen sites and provided with diversions so that the runoff flows onto wooded or grassed areas having soils of good infiltration quality. If the contaminated runoff is prevented from reaching streams through overland flow, surplus water supplies are protected. Generally, the ground water is amply safeguarded by the filtering effect of the soil. The exceptions may be very coarse sands, sands that are shallow, or fractured rock that reduces the effectiveness of the filtration action. In some soils, the filtering effect can be enhanced by artificial drainage to lower the water table or remove filtered liquid. In rare congested circumstances, disposal of the material by irrigation may become impractical or objectionable. In such cases, there needs to be developed an economical and effective means of handling manure to provide some benefit to the land while eliminating possible pollution from runoff.

**Plant Nutrients**–Ponds, lakes, reservoirs, and rivers frequently are degraded by growth of algae and other plants. Increased water temperatures caused by low flows, increased solar heating following removal of vegetation, or other causes, may be a significant factor in algae growth. Algae, like all plants, require mineral nutrients for growth. In most waters, the limiting factor for algae growth is phosphorus. The other elements, such as nitrogen, potassium, calcium, and magnesium, are usually in abundant supply. Evidence indicates that algae will grow if the water contains as little as one-tenth of a part per million of phosphorus. Farmers often supply many tons of fertilizer containing phosphorus on their farms, and considerable phosphorus is present in domestic sewage from the use of laundry detergents. The average amount of phosphorus delivered in metropolitan sewer effluents amounts to about two pounds per person per year; in other words, the sewage effluent from a city of a million people will contain 1,000 tons of phosphorus a year. Phosphorus from farm lands may also pollute streams; however, it gets into the surface water mainly through erosion sediments and runoff from topsoil. It is possible that surface runoff flowing into streams from feedlots and barnyards may be a significant source of phosphorus; however, water that seeps through the subsoil or moves laterally through the soil carries very little phosphorus. Phosphorus normally moves only a few inches through a soil before it is "fixed" by iron and aluminum.

Soil particles have a great affinity for holding phosphorus molecules. When, for example, fine

[1] C.H. Wadleigh, ARS. Agricultural Pollution of Water Resources, Soil Conservation Mag., V. 33, No. 2. Sept. 1967.

[2] Dr. L.T. Cardos, Pennsylvania State University.

suspended soil particles in the river contain a thousand parts per million of phosphorus adsorbed on their surfaces, the phosphorus in true solution may be only 0.005 to 0.010 parts per million.[1] Water samples are sometimes analyzed without making a distinction between the phosphorus that is in solution and the phosphorus which is adsorbed onto the suspended sediment and therefore is relatively inactive. In any event, the best way to control the phosphorus burden arising from agricultural practices or from construction is to use practices which prevent erosion of the land. These practices are structures, vegetation, and drainage facilities which minimize surface runoff and delivery of sediment from fields, farmsteads, feedlots, and disturbed areas, and encourages percolation through the soil.

**Infectious Agents**–Otherwise attractive streams may become unsafe for swimming or potable uses because of the presence of pathogenic bacteria or infectious virus agents. Some of the bacteriological pollution in streams comes from farm runoff and erosion as well as from erosion due to construction, logging, and other sources. In places where infectious pollution is found to be a problem from specific sources, it may become necessary to collect and treat the effluent by adequate means before discharge.

**Organic Chemical Exotics**–Much public concern has been expressed over possible poisoning of the environment by organic chemical pesticides and herbicides. The Senate Select Committee on Water Resources states that organic chemical pollutants constitute a "water problem of great concern which will increase manifold in significance in the future." Synthetic detergents, petroleum derivatives, and nitrochlorobenzenes are some examples of chemical pollutants that frequently originate from industrial and metropolitan areas. Others may originate from productive lands, mainly from use of pesticides that are somehow applied so that they reach streams and lakes directly or by overland flow before they have oxidized. Organisms normally in the soil have a large capacity to oxidize most such chemicals.

According to Leo G.K. Iverson, Assistant Director of the Plant and Pest Control Division, Agricultural Research Service, pollution of water from the proper use of organic pesticides may not be as extensive as formerly believed. The use of "hard" or persistent chemical compounds such as DDT, Dieldrin, Aldrin, Heptachlor, Endrin, Lindane, and Chlordane is being decreased in the State of Washington. Alternate chemicals are being used which have a short half-life and are broken down before they reach surface and subsurface waters. Despite this action, however, continual alertness is required to minimize any potential danger from the use of potent chemicals, regardless of the source.

**Salts and Minerals** Water moving through soil extracts natural salts and minerals. Drainage from mines, and salts in the wastes from certain industries, are other examples. Usually these problems are more potent in the arid and semi-arid regions than in the Puget Sound Area, where accumulations of salts are usually leached from the soil in a short time by the favorable rainfall pattern. Logging operations, road construction, and housing developments that disturb large areas of soil, may temporarily increase salt and mineral concentrations in waters derived from these areas.

**Cover Crops** A good cover crop on suitable soils sometimes provides an economical oxidation system for the safe disposal of organic wastes, such as remain after the usual treatment of effluent from food and fiber processing plants and, in some cases, from municipal sewage systems. Careful regulation of the use of organic wastes is essential to prevent contamination of food crops which may be eaten uncooked, to prevent unnecessary exposure of the public to pathogen-laden water, and to avoid nuisances.[2]

Studies made at Pennsylvania State University by Dr. L.T. Cardos and associates of treated municipal waste disposal found that chlorinated effluent from municipal sewage treatment plants could be used to irrigate corn, wheat, red clover, alfalfa, idle farm lands, mixed hardwoods, and red pine at the rate of one to two inches per week through sprinkler irrigation systems. In these cases, the concentration of nitrate in the soil water below 12 inches was reduced 68-80 percent from that of the applied effluent; phosphorus, 99 percent; and detergents, 95-98 percent. In addition, with two inches of irrigation per week, over a million gallons per acre of high quality water was recharged to the ground water reservoir for potential re-use during a period of five and one-half months. Sites for such irrigation should be carefully selected and storage should be provided so that irrigation need not be accomplished during

1 C.H. Wadleigh, ibid.

2 Health Guidelines for Water Resource and Related Land Use Management. U.S. Public Health Service, Department of Health, Education and Welfare. March 1968.

the brief and erratic periods when drainage would be hindered by frozen soil.

Where pesticides, animal wastes, infectious agents, phosphate, and silt move overland from the land to the streams and result in water pollution, then the important control should be on runoff and sediment delivery since these are the major vehicles for pollution. This could mean that practices which prevent erosion of the soil should be applied more thoroughly and effectively to critical watershed areas as population pressure increases than they are today.

Sediment resulting from the erosion of building sites, road construction, and agricultural lands, including logging, is a major form of water pollution and soil conservation practices are an accepted means of control.

## Drainage for Transportation Systems and Foundations

The stability or life expectancy of a road or a low building or airport depends basically upon two things–the soil beneath the foundation and water conditions. Roadways and other structures constructed over suitable soils are cheaper to build and easier to maintain than those which are built over unsuitable soils.

The supporting capacity of various earth foundations varies from several hundred tons per square foot for solid rock to practically nothing for saturated silt and depends upon: (1) the characteristics of the formation; (2) the bedding and stratification of the particular formation; and (3) the degree of saturation of the formation with water.

Flood plains and alluvial deposits generally are non-homgeneous in their composition and must be studied with care to determine the proper bearing to be assigned to them. Their weight-bearing capacity will generally be determined by the most porous material in their make-up. Glacial deposits may vary from pockets of small size to formations covering a wide area, and their extent must be studied when such formations are utilized as foundation beds. Thin strata of rock, especially when badly fissured, afford very little better foundation beds than does the stratum beneath the rock. Solid rock should mean a solid, infissured stratum not less than 10-15 feet thick. Muck and peat soils almost invariably settle when subject to loads, and foundations should be built upon them only with extreme caution.

Not only should the present condition of the soil be taken into consideration, but its probable

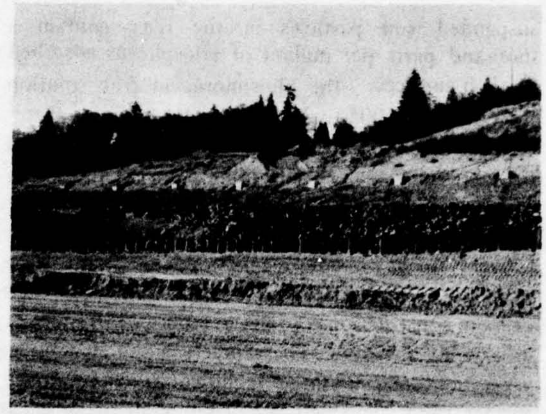


PHOTO 2-20. Roadcut, showing piling and rock riprap to prevent slide in clayey lake sediments, King County. Note use of numerous drainage wells and pumps to remove excess ground water in an effort to stabilize the soils. (SCS)

behavior when exposed to the weather. Many formations, such as some shales and clays, disintegrate and change their properties if exposed to the weather.

Colloidal, or ultra-fine materials, particularly clay and humus, affect the bearing behavior of soils. The influence of the colloidal content lies in increased impermeability to movement of water, greater capacity for retaining water, and increased shrinkage upon drying. Colloidal materials, particularly clays, also diminish internal friction between larger soil particles when wet and thus lessen load-bearing capacity unless drained. The proportion of colloidal material in a soil may vary from a trace to nearly 100 percent. Loam soils usually contain 20-25 percent colloids, while coarser-textured soils contain less.

## Behavior of Water in Soils

When water occupies all interstitial space in a soil, the soil is said to be saturated. Foundations set below the zone of saturation are subject to water infiltration unless carefully waterproofed and, in most situations, are subject to upward buoyant effects acting on most of the submerged foundation.

Under some conditions, water may be under a hydrostatic head causing upward flows when released by excavation or other disturbance. This flow in fine materials may result in "quick" conditions that destroy the load-bearing capacity of many soils for normal foundations.

Water also exists in soil above the saturated zone in the so-called capillary fringe. The elevation of this fringe above the zone of saturation is greater in fine soils where conditions for capillary rise of water are good. Freezing of water, either in the saturated zone or in the capillary fringe, causes an expansion known as "heaving." The expansion by heaving is not necessarily uniform and results in uneven bearing on the foundation. Heavy foundation or traffic loads under these conditions cause breaking or displacement and result in heavy damage.

Effects similar to frost heaving are derived from the tendency of some soils to expand when wet and shrink when dry.[1] Relief from these effects is obtained by installation of drainage measures combined with other measures to insulate the soil mass from fluctuations in moisture content.

In general, the two methods of combating freezing or shrinking are to remove the water from beneath the foundation, or to put the foundation down to such an elevation that frost or changes in moisture do not occur beneath it. In the lowlands of Puget Sound, usually two feet will be beneath the frostline, but in the northern counties and higher mountain areas, frost penetrates to greater depths. Treatment for preventing frost heaving or damage from freezing is to remove the water from beneath the highway and carefully prepare the subgrade out of select materials having low capillary attraction.

Basically, this drainage may be provided by open drains or closed drains. Surface drainage is usually of two types: (1) interceptor ditches which intercept and convey water away from the roadbed before it enters the subsurface of the road; or (2) ditches which are deep enough that water drains from beneath the road into the ditches and is conveyed

Subsurface drains, commonly known as "French drains" or "drain pipes," are placed beneath the surface of roads and are usually filled with coarse aggregate or gravel. They are placed at a grade which will convey water from beneath the roadbed to ditches or pipes outside. A French drain consists of an excavated trench backfilled with stones, the largest stones at the bottom and the size decreasing toward the top. It should be built on a grade steeper than a pipe drain and deep enough to avoid freezing. French drains have a tendency to become clogged unless well maintained. Pipe drains may be built with clay tile, vitrified clay pipe, concrete pipe, corrugated metal pipe, or plastic pipe. The drain is usually laid on a grade with open joints at the bottom of a trench backfilled with coarse gravel. Pipe drains may be located either beneath the roadbed or beneath ditches at the side of the road. They are constructed at intervals as necessary to provide the required drainage.

[1] See Exhibit 1, Table 15 at the end of this Appendix.

## Drainage for Disposal Field Development

It is possible that drainage facilities can lower the water table sufficiently to permit septic tanks to function at specific sites where otherwise the water table is so high drainage fields will not function. Artificial drains should be designed to promote the effective filtration and aeration of effluent and not to merely pipe the effluent away to cause trouble elsewhere.

About 1,983,000 acres have moderate to severe limitations for use of septic tanks. These lands consist of 391,600 acres of alluvial flood plain lands, 209,000 acres occurring as basin areas in upland terraces, 1,300,000 acres of restrictive or cemented till, or underlain at shallow depths by bedrock, and over 82,000 acres of organic soils, and other unstable or hazardous areas.

Septic tank drainage fields on gently sloping to hilly land may cause seepages and springs at lower elevations and become a serious health hazard. Likewise, they contribute to higher water tables in the gently sloping basins which, under natural runoff conditions, require surface and subsoil drainage during periods of excess precipitation. Septic tank drainage fields occasionally contribute to slides and land loss in areas otherwise relatively stable.

## Drainage for Recreational Areas

Types of drainage in recreational areas are diverse, since the areas are concerned with roads, buildings, campsites, septic tanks, grass seedings on golf courses, woodlands, and wildlife. Drainage often is required to remove free water from surface soils and subsoils to improve sites for parks and golf courses or trees and shrubs. Drainage for recreational purposes is closely related to needs for agricultural drainage.

Many recreational sites and vacation homes are located on the shores of glacial lakes where soil conditions often result in low permeability. Pollution from septic tank fields, sediment, and accumulations of waste are particularly difficult to keep out of lake waters under these conditions. Collection and com-

munity disposal of sewage, with careful control of erosion conditions, are highly advisable.

### Drainage for Vector Control

Various features of erosion control, sanitation, drainage, and other water management, affect vector habitat and the prevention and control of vectors and other insect pests associated with water and related land resources. Major vectors include mosquitos, terrestial anthropods, and rodents associated with the management of the water and land resources. Improved water management includes the potential for establishment of physical conditions that may minimize or eliminate existing vector problems and produce substantial benefits in comfort and health of populations of humans and domestic livestock.

Routine programs of vector appraisal are desirable as a part of normal operation and maintenance activities of water resource projects, particularly those involving irrigation, reservoirs, and water-oriented recreational areas. Inspections for adult and larval mosquitos and other vectors are essential for planning and evaluating control measures to meet potential or emergency situations involving vector-borne disease. Personnel of the Washington State Health Department can provide assistance in evaluating potential or actual vector control needs.

## IRRIGATION

Irrigation in the Puget Sound Area offers the advantage that a comparatively small amount of supplemental irrigation during the summer can be used to supplement natural rainfall occurring during the growing season and available soil moisture stored from previous rainfall to approximate optimum soil moisture conditions for crop growth. An exception to the supplemental nature of irrigation occurs generally in the rain shadow of the Olympic Mountains where substantial amounts of irrigation are required for satisfactory growth of most economic crops.

In 1966 about 91,700 acres[1] of land were irrigated. Under present conditions much irrigation is practiced during extremely dry periods to avoid crop failure and to establish new seedings rather than to obtain maximum crop yields possible with the best management. The greatest improvement in production is realized when irrigation is integrated into total farm management. Where irrigation is used only to rescue crops from the obvious effects of temporary drouth, part of the potential benefits of the supplemental water are foregone.

Much irrigation is installed by individual farmers pumping from ground water supplies or diverting from small streams and private impoundments. Project type developments for supplying water are found in the Elwha-Dungeness Basins. Farmers can be expected to install substantial amounts of irrigation facilities in response to improvements in the market for farm produce that may justify the investments required. If the Area satisfies the requirement for food and fiber projected by Appendix IV, Economic Environment, on the land estimated to remain in cropland, there will be a need for 396,000 acres[2] of irrigation, including the 91,700 acres presently irrigated, by the year 2020 (see Table 2-12). Appendix VII, Irrigation, projects the total acreage likely to be irrigated in the Area at 223,000 acres.[3] If this projection is correct, the corresponding deficiency in production will increase the existing dependence of the Area on imports of farm products to meet the needs of future years.

Part of good management of supplemental irrigation lies in adjusting the timing, frequency, and amounts of water supplied to specific crops. This requires a higher degree of water management than is in general use in the Area. Under present conditions this level of water management is practical only on the better adapted soils having good characteristics for storage of water in a form available to crops. This means usually that flood protection and adequate drainage are required before irrigation can be managed for best economic advantage.

Irrigation can supply water before growth of the plant is slowed or stopped by lack of water, but excess water likewise will inhibit plant growth. Nearly

[1] Appendix VII, Irrigation, reports the functional aspects of irrigation supply and related factors.

[2] Appendix V, Water-Related Land Resources, Chapter 2, Agriculture.

[3] Appendix VII, Irrigation, Table 2-12.

all crops grow less rapidly when soil moisture falls below 20 percent of the water-holding capacity of the soil. Some crops are similarly affected when 35 or 40 percent of the available moisture remains in the soil. High fertility levels may affect the optimum moisture level. Irrigation and higher applications of fertilizer often make it possible to increase the density of some crops, i.e., the number of plants per unit area, without impairing growth of the individual plants. Variations in moisture affect the quantity and quality of the crop in degree, and irrigation practices should be continuously adjusted to conditions of available water, soil temperature, and crop for best results. The actual application may need to be adjusted to fit crop maturity, quality considerations, or for other reasons. The moisture content of the soil can be measured or estimated by various methods. The irrigator should become experienced in at least one accurate method of determining available moisture in the soil and use the information in management of the water to achieve best results.

Benefits from supplemental irrigation increase gross income and generally increase net income to the extent required as an incentive for private enterprise to undertake the investment, provided more pressing needs for production efficiency have been met.[1] It has been found that lack of a reasonable return from farm operations often has the effect of increasing the tendency to neglect timely installation of rehabilitation and protective measures not immediately related to current income. Irrigation is a factor in production and to the extent that this increases the stability of the agricultural enterprise, it is expected to contribute to the welfare of the watershed lands for hydrologic and other environmental benefits of open land use.

Forest studies[2] indicate there is a potential for irrigating forest lands for increased production. There is a potential of 634,900 acres considered available for this treatment. Such irrigation has the potential for increasing production for future years but the economic feasibility has not been determined.

[1] Appendix V, Water-Related Land Resources, Chapter 2, Agriculture, Exhibits 6 and 7.

[2] Appendix V, Water-Related Land Resources, Chapter 3, Forests.

# WATER YIELD IMPROVEMENT

Portions of this Appendix deal with the protection or rehabilitation of watershed lands. These measures are aimed at the maintenance, insofar as possible, of the natural hydrologic balance, thus minimizing the effects of land use development in watershed areas. A complex part of watershed management involves the field of water yield improvement. The natural hydrologic balance, however effective it may be in soil stability and control of erosion, may not result in the optimum production of water in terms of either quantity or quality. Measures for water yield improvement, therefore, involve the deliberate management of upstream lands to increase the total yield of water or to significantly change the timing or period of runoff. These measures may be structural in nature, they may involve the manipulation of vegetative cover, or may be combinations of both.

The reader should recognize at once that very few watersheds in this country are now being managed with the objective of regulating water yield. Despite the prevalence of municipal watershed areas, the Puget Sound Area is no exception. There is management to protect water quality—a good deal of it—yet there is virtually none, other than research, devoted to the improvement of natural water yields. Current water yield, including that from municipal watersheds, is basically a natural, unmanaged product.

There are many reasons for the apparent lack of management in water yield improvement. Most of these stem from the complexity of the subject, from a general lack of knowledge concerning the hydrologic character of upstream areas, and from a lack of specific goals for water production.

A number of studies throughout the nation have proved conclusively that vegetative manipulation can affect total water yields. Indeed, this is precisely what has happended where, through indifferent or unknowing land development, the natural water balance has been affected to the point that flooding, erosion, and sedimentation have occurred. These

results are destructive and consequently are well known, yet there is an equal opportunity for improving the yield of water through careful land use planning and the use of measures specifically designed for this purpose. The studies have shown conclusively that a large potential exists in the field, but nearly all admonish the reader to proceed with caution. It is generally agreed that considerably more information on the various factors involved is needed prior to any widespread application to management.

Vegetation influences water in two ways: (1) it slows the rate of runoff, allowing more time for infiltration and increasing the time required for concentration of runoff water, and (2) it uses water. These processes are due to: (a) interception by vegetative crowns which catch and temporarily store moisture until it evaporates; (b) infiltration and percolation of water into and through the soil; (c) transpiration and use of soil moisture by vegetation in its growth process; and (d) evaporation of moisture not included in interception. Water supplies can be controlled to the extent that these processes can be modified. (See the section of this Appendix dealing with "Effects of Soils and Cover on Runoff").

The infiltration of water into the soil profile depends basically on two factors: the rate at which the water is capable of penetrating the soil profile; and the time free water is available to enter the soil. Vegetation assists in this process by slowing or retarding the rate of runoff, thereby allowing more time for infiltration to occur. Plant roots assist also by penetrating the soil profile and breaking it up or loosening it to allow for more rapid infiltration. The infiltration rates or intake rates, and the water holding capacities of Puget Sound Area soils can be found in Exhibit 1, Table 6. The infiltration rates are given in inches per hour, indicating the importance of time.

One means of increasing water yield is through forest cutting or other vegetation removal. This is logical, since cutting reduces water losses through vegetative interception and transpiration. There is less time for infiltration, less moisture is returned to the atmosphere, and more goes into streamflow. In moist climates such as that of the Puget Sound Area, it is estimated nearly one-third of the annual precipitation is lost due to these processes. While not all of this water could be recovered by cutting, it is obvious that greatly increased water yields could result from cover removal.

The timing of the water yield is the critical question in this instance. Studies have shown that total flows generally increase with cover removal, but these increases are the greatest during periods of high flow and are relatively insignificant during periods of lowflow. This is not a desirable objective in the Puget Sound Area. While some studies have shown that low flow augmentation may occur in some instances, generally low flows are decreased. Much more research is needed in this field.

A second means of altering water yield is available through conversion of cover types or the replacement of heavy water-using species with other less demanding types. The removal or replacement of certain riparian vegetation, particularly, could be instrumental in improving low flows during the summer months. Undoubtedly there is considerable potential for this type of work throughout the Puget Sound Area but the total scope or effect is unknown.

Possibly the most likely chance for successful improvement of water yields lies in the management of snowpacks in timbered and alpine areas. This has particular significance in the Puget Sound Area, since much land receives a large portion of its annual precipitation in the form of snow. This land constitutes an important source of streamflow during the summer months. Annual snowfall rates exceeding 500 inches are found in the Olympic Mountains and the Cascade Range. The delayed action of snowmelt effectively stores precipitation from the winter months in which it falls to the spring and summer months in which it is needed.

Some of the winter precipitation which falls as snow serves to continue the life of the approximately 674 glaciers to be found in this Area. These glaciers, with a total surface area of 153 square miles, contribute about 1,430,000 acre-feet annually to Washington streams. It is estimated that about 400 million acre-feet of water are currently stored as glacier ice in this State.

The streamflow from glaciers has several distinctive characteristics of particular importance to resource development in the Puget Sound Area. The most important of these characteristics are: (1) the fact that precipitation is stored in the winter and released during the summer dry periods, particularly during July and August; (2) the fact that although runoff from glaciers is approximately equal to the precipitation when averaged over a long period of time, the ice reserves are so vast that in the hot, dry years when runoff from other than glacier sources may be in short supply, the glacier melt can exceed

the total precipitation, and in the years in which precipitation is appreciable, large amounts of water can be stored; and (3) the fact that the natural storage of frozen water in the glaciers is virtually free from evaporation, transpiration, and other losses. Although the total streamflow from glaciers within the Area is a small proportion of the total runoff, the conditions under which it is and can be released make it of considerable importance.

A number of studies have shown that cover manipulation, as well as snow fencing, can result in greater concentrations or accumulations of snow, thus reducing evaporation losses. Cover can be utilized to shade the snow, resulting in lower melt rates and prolonged streamflow. Again, the various processes involved do not always complement each other. It is recognized that measures designed for maximum snow accumulation may not serve equally well in reducing melt rates. Other factors, including topography, aspect, air movement, or elevation, exert a considerable influence. Then, too, unusual conditions must be contended with. A program for snow accumulation must consider the effects of rain-on-snow conditions, such as those that were instrumental in causing the floods of Christmas week, 1964.

The potential for water yield improvement through snowpack manipulation is considered to be high, yet much more needs to be learned about the various processes involved. Certainly this subject deserves intensive research and analysis to determine its potential in the Puget Sound Area.

The foregoing paragraphs have pointed out that much information needed for managing water yields is unavailable. The information required is not so much concerned with how the cover may be manipulated, since much of this is available, but rather where and under what conditions. Deficiencies in the information include data related to hydrology, geology, soils, silviculture, climate, and economics. There is virtually no information which relates to the cost of a program for producing an acre-foot of water at the time it is wanted. In addition, many landowners or managers do not consider water as a production goal, since it provides no monetary return for their management. Those who do, frequently are placed in the position of guessing what the future demand for water will be. Until there is general awareness of the role of land in water production; until specific goals for the production of water from these lands are established; and until land managers are provided with the basic data and incentives needed for making their management decisions, the full potential for land-based water yield improvement cannot be realized.

## THE ROLE OF FORESTED LANDS

Watershed management practices on forested lands are dependent, to a large extent, on the uses to which the lands are put. Forests are used for timber, occupancy, recreation, fish and wildlife, forage, and other purposes, as well as for the production of water. The type of uses involved, singly or in conjunction with one another, largely determines the measures required for soil and water protection. Water yield improvement, on the other hand, is mainly directed toward improving natural water yields and, to a lesser extent, correcting deficiencies that have occurred from land use development. The following paragraphs summarize the development potential for each of the major forest land uses, as discussed elsewhere in the Puget Sound report. These projections provide the basis for the soil and water protective measures listed for each river basin.

**Management**–Currently, one of the greatest potentials relative to forest land is management that recognizes the role of land in water production and adequately provides for the protection of soil and water values. There are some 1,650,000 acres of forest land in the Puget Sound Area that are now under low levels of management. In addition, much of the remaining land is managed at a level below that needed for optimum water yields.

**Protection and Restoration**–The development of forest lands for the various goods and services they provide uses a variety of measures for the protection of soil and water values.

Protective measures used in road construction include adequate survey and design, surface drainage, stream crossings, and stabilization of disturbed soil areas. These measures should receive adequate consideration and use in future road development.

Occupancy, or the use of forest lands for summer homes, resorts, or like developments, is projected to utilize some 347,000 acres of forest land by the year 2020. Needed soil and water protective measures are essentially the same as those discussed under recreation.

Natural disasters, including fires, floods, storms, insects, and diseases, will continue to pose problems in forest land management. Adequate fire control and

detection of insect and disease attacks should be provided for the total forested area, currently 6,359,000 acres excluding open land normally associated with forest. Following any of these occurrences, adequate measures for rehabilitation and soil stabilization should be initiated.

**Potential Projects**—There is a large, but unrealized, potential for the improvement of water yields from forest lands. Various techniques, including cover conversion, snowpack management, or the development of structural facilities, can materially affect the quantity and quality of water from forested watersheds. Unfortunately, too little is known of several aspects of this complex subject to allow any widespread application of the techniques at the present time. There is, in addition, very little consideration of this potential in current land use planning. The primary needs at the present time may be defined as:

1. The establishment of goals and management objectives as previously discussed under "Management."

2. The provision of needed data on hydrology, geology, soils, silviculture, climate, and economics as related to forested watersheds.

3. The development of management incentives such as providing a return to managed lands for benefits effective in offsite, downstream areas.

# INSTITUTIONAL STRUCTURE

The development and use of land and water resources in the Area has passed through historical periods beginning with an era of exploitation when there was very little management or regulation for future use. The early exploitation has given way to the present situation where increasing competition is coupled with greater concern for sustaining resource values for the future, and when increasing management effort and regulation assists in this purpose. It now appears that rapid economic and population growth will cause the Area to pass into a condition in which management must become intense and regulation must further increase if sustained use of water and land resources is to be coupled with retention and improvement of environmental qualities.

Some management measures are for rehabilitation and protection of resources and consist of: (a) treatment to restore damaged resources as nearly as practical to their former state of reserve productivity; (b) use of land within its capability; and (c) treatment according to use to prevent further deterioration of soil and water resources. Other measures are required to develop resources for production efficiency and environmental betterment. The amount of management effort expended along these lines is now considerable; and this effort, coupled with the natural ability of the Area's land and water resources to recover from damage, has succeeded in maintaining a relatively effective hydrologic balance and in holding sediment delivery below that in many parts of the Nation.

These efforts will not be adequate for future years, however. The collective weighted level of accomplishment of management on forested lands is estimated at about 40 percent efficiency in terms of present justifiable implementation and must be increased to meet future needs.[1] A partial record of measures for watershed protection and management accumulatively applied on cropland is provided in Table 2-8. The Table indicates in a general way the kinds and amounts of measures maintained on cropland as of 1966. Many of the measures need intensification on the acres reported. A somewhat subjective judgment is that, while these measures may meet present production requirements, they represent collectively about 40 percent of the implementation needed for protection and future development.

The rapid increase in population and economic growth projected through the year 2020 creates an emergency condition within the Puget Sound Area requiring great effort to be expended if productive use and environmental quality are to be sustained at reasonable levels. Failure to sustain and improve these values would result in large costs through opportunities foregone.

Some of the measures, once installed, are fairly permanent improvements; others require periodic renewal. All measures require careful maintenance to insure effectiveness under conditions of use. These activities require a continuing investment of public

[1] See Present and Future Needs section of this Appendix.

**TABLE 2-8. Measures for watershed protection and management on cropland[1]**

| Treatment Measures | Unit | Accom-plished |
|---|---|---|
| **Erosion Control Measures** | | |
| Conservation cropping system | acre | 210,600 |
| Pasture and hayland planting[2] | acre | 10,000 |
| Cover crop[2] | acre | 24,000 |
| **Flood Prevention Measures** | | |
| Dike and levee | feet | 1,443,790 |
| Clearing and snagging | feet | 211,500 |
| Streambank protection | feet | 892,500 |
| Stream channel improvement | feet | 459,580 |
| Stream channel stabilization | feet | 25,350 |
| **Drainage Measures** | | |
| Drainage main or lateral | feet | 7,042,420 |
| Drainage field ditch | feet | 81,470 |
| Tile drain | feet | 5,790,860 |
| **Irrigation Measures** | | |
| Irrigation system, sprinkler | number | 2,210 |
| Pipeline | feet | 288,500 |
| Irrigation water management | acre | 91,700 |
| Irrigation pit or regulating reservoir | number | 320 |
| **Recreation Measures** | | |
| Recreation access road | feet | 1,105,350 |
| Wildlife habitat management | acre | 107,180 |
| Farm pond | number | 1,010 |

[1] Measures applied cumulatively through 1966, as recorded by SCS.

[2] Conservation measures applied annually.

and private funds for installation, maintenance, and renewal.

Land administering agencies of the State and Federal Governments are responsible for these costs on lands in their custody, while private owners are responsible for most of the costs on private lands. Various agencies of the State and Federal Governments[1] maintain programs of technical, financial, and credit assistance to individuals, local organizations, and subdivisions of government in accomplishing this work. Many forms of regulation are employed and a recent (1968) amendment to the State Constitution will make it possible to employ preferential taxation in addition to other incentives for proper use and management of land and water resources.

The present level of agricultural development in much of the Area is limited by lack of effective community-type structural measures to reduce damages from floodwater and sediment, similar measures for providing agricultural water management, and measures for improving production efficiency. Low net returns to farmers (1968) discourage high rates of investment in irrigation and other improvements primarily for increases in production until more pressing measures of a protective nature are installed.

Many existing urban areas need additional protection from floodwaters that cause overloading of combined sanitary and storm drainage, and for increasing security against damage to property. Zoning can be a useful tool in control of water drainage damages and in preserving water quality.[2] Many urban areas face substantial costs in attaining and preserving needed levels of pollution protection. New developments should include safeguards when construction is planned.

Many of these problems suggest that the entities which now plan, finance, install, and maintain drainage systems near urban developments are too small to take care of the problem. The problem requires that an inventory of the present and future needs be established for all waters within the watershed, whether they originate within city boundaries or in the countryside, and the treatment and needs should be integrated and projected for the life of the system. This will apparently require larger districts and greater powers, not only for the conveyance of water but also for the economical zoning of industrial and urban developments so that these needs may be cared for in an economical manner. In the planning process, a need arises for accurate large-scale aerial surveys and mapping. Where possible, future urban areas should be intermixed with an associated but planned open space for buffering purposes so that the flows can be kept under control. In some cases, structures to provide augmentation of low streamflows for pollution abatement and other purposes should be included.

As early as 1895[3] the first drainage districts were formed to solve the subsurface drainage problem in pockets of agricultural land. A little later, urban developments began to solve their drainage and surface water problems by installing storm and sanitary sewers. Many of these developments do not have sanitary sewer systems; and in some cases,

[1] See Appendix II, Political and Legislative Environment, for agencies providing various forms of assistance.

[2] See Appendix XIII, Water Quality Control.

[3] Department of Water Resources, State of Washington.

improperly treated or filtered effluent of septic tanks and cesspools enters the drainage system, giving the water derived from these areas a different character than that derived from agricultural land.

At present, there are over 400 special governmental units in 12 Puget Sound Area counties that have by statute some form of control over water, either in its procurement and distribution for its disposal. While many of these entities overlap in territorial boundaries and in functions, there are still many areas of the Puget Sound being developed where no authority exists for water management. See Table 2-9 for the number of these governmental units, by counties, existing as of 1966.

**TABLE 2-9. Governmental units having some statutory control over water[1]**

| Counties | Cities & Towns | Townships | Flood Control & Flood Control Zone Districts | Public Utility Districts | Water & Water Distribution Districts | Sewer Districts | Diking & Drainage Districts | Diking Districts | Drainage Districts | Drainage, Diking & Sewerage Improvement Districts | Reclamation & Irrigation Districts |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Clallam | 3 | | | | | 1 | | | | | 4 |
| Island | 3 | | | | 4 | 1 | | 4 | 5 | | |
| Jefferson | 1 | | | 1 | | | | | 1 | | |
| King | 31 | | 12 | | 57 | 25 | | | 11 | 3 | |
| Kitsap | 4 | | | 1 | 20 | 6 | | | | | |
| Mason | 1 | | 2 | 2 | | | | | | | |
| Pierce | 18 | | | | 12 | 2 | | 1 | 8 | 2 | |
| San Juan | 1 | | | 1 | 1 | 1 | | | | | |
| Skagit | 8 | | | 1 | | 1 | 9 | 16 | | | |
| Snohomish | 17 | | 2 | 1 | 13 | 2 | | | 4 | 11 | |
| Thurston | 6 | | | | 1 | | 1 | | 4 | | |
| Whatcom | 7 | 19 | | | 5 | | | 3 | 9 | 14 | |

[1] Data from Department of Water Resources, State of Washington. Information was not available for the small portion of Lewis County included in the Area.

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# PRESENT AND FUTURE NEEDS

## GENERAL NEEDS

The needs of the Area begin with consideration of the numbers of people and the combination of their requirements, both individually and collectively. Space requirements for various purposes should be fitted, as well as is practical, to the lands best suited for these purposes. Many land areas provide multiple-purpose uses.

Space requirements for development to meet the needs of the expanding population depend on the future density of settlement. It is expected most of the new population will be urban oriented but urban populations can be dense or sparse. Typical urban development in the past has been rather leapfrog fashion in search of cheap land and other real or fancied objectives. The pattern thus begun will result in large economic costs to the public in furnishing services and in opportunities foregone for improving the environment. Scattered development of the land and water resources is often wasteful and frequently inequitable, in that some costs which should be borne by the entrepreneur are passed on to the public.

Much of the need found at this time is for better planning to protect the interests of the public and the environment for the future. Population is expected to increase from about 2 million in 1967 to 4.3 million by 2000, and 6.8 million by 2020. During the period of this increase, the needs of the public, as contrasted to those of the individual entity, will assume greater importance. Clean water, clean air, and room for recreation are requirements among many others–including moderately priced food, shelter, and services–that are desired by the public. These things, if provided, will require public investments in terms of taxes, interest, etc., but will be far more economically and satisfactorily provided at this time than in later years.

The kinds of needs considered here are the measures required to promote stability of the soil mantle, to reduce degradation of the water and land resources by flooding, swamping, and sedimentation, and to provide better management and development, with protection, for multiple uses of the watersheds.

The needs most apparent now are those to correct exploitation and degradation of the environment and provide for reasonable density and efficiency in present and future development. Needs for legislation, policy clarification, and further study are discussed in the Means to Satisfy Needs portion of this Appendix, and not repeated here.

The principal watershed management needs of the Area are described in three categories: (1) land in urban use with an assumed average population density of six persons per acre; (2) land in agriculture, or other low-density use; and (3) other areas.

### NEEDS OF URBAN LANDS

Lands in or expected to be developed for urban use often require characteristic protective measures. Improvements generally needed are better selection of land for varied uses and installation of measures to reduce flood hazard, improve urban drainage, stabilize soils, reduce hazard of pollution, and reduce costs of furnishing public services. When developments are based on good planning, these intensive improvements can frequently be provided, on well-adapted sites. Environmental factors of open space and recreational sites can often be provided in areas considered unsuited for many types of construction. Improvements to established developments will require large investments of capital and considerable time for installation but provision to meet these needs in new developments can be incorporated with a large saving of public and private costs.

In order to project the gross area of urban lands needing such treatment, future alternate average densities of six persons and ten persons per acre of urban use were compared. These densities are assumed to largely bracket the intensities likely to develop. A minimum average density of six persons per acre was used to estimate the area required for developed use, and to estimate treatment required (Table 2-10). Lesser densities cause rapid increases in cost of public services.

**TABLE 2-10. Urban lands needing treatment**

| Year | Flood Prevention: Density of Six Persons (acres) | Flood Prevention: Density of Ten Persons (acres) | Watershed Protection and Rehabilitation: Density of Six Persons (acres) | Watershed Protection and Rehabilitation: Density of Ten Persons (acres) | Drainage: Density of Six Persons (acres) | Drainage: Density of Ten Persons (acres) |
|---|---|---|---|---|---|---|
| 1963 | 91,671 | 91,671 | 667,184 | 667,184 | 667,184 | 667,184 |
| 1980 | 101,800 | 91,671 | 731,289 | 667,184 | 731,289 | 667,184 |
| 2000 | 101,800 | 91,671 | 799,307 | 667,184 | 799,307 | 667,184 |
| 2020 | 101,800 | 91,671 | 1,040,121 | 675,900 | 1,040,121 | 675,900 |

## NEEDS OF LANDS IN LOW DENSITY USES

Lands in low density uses—croplands, forests, and other lands—furnish food and fiber, recreational opportunities, and esthetic values. Such lands also provide the water supply and determine to a large extent the nature of the environment enjoyed by the public. Much cropland and forest is in private ownership and must be used and developed under good conservation management to remain in good condition, yield a return on investment and labor, and preserve its beneficial aspects. The public thus depends on individual owners to protect and maintain many desirable qualities of the environment, and the proper use and maintenance of privately-owned lands is in the public interest. Some of this land is administered by Federal or State land management agencies who manage the land on behalf of the public.

### Croplands

Much of the best cropland is located on the flood plains of major rivers and tributaries and requires protection from floods, erosion, swamping, and other damages, although not at the high security level of urban developments.

Both drainage improvement and irrigation will require at least moderate prior protection from overbank flooding and sedimentation in areas where these conditions persist. Floodwater damage must be prevented to the extent the hazard remaining after protection does not materially exceed other risks before development measures become practical. The level of protection needed may increase in future years as the investment in agriculture increases. In some cases lesser levels of protection have been deemed profitable. Reduction of flood damages is needed on 454,400 acres of farmland, and measures to accomplish this should be installed before 2020 (see Table 2-12).

Watershed protection and rehabilitation measures needed are a combination of vegetative and structural measure selected on the basis of land use to supplement the natural defenses of the land against excessive soil loss.[1] When the use is properly fitted to the capability of the land, the cost of treatment measures is nominal; but where the use exceeds the capability, the cost of effective protection may be excessive. Erosion prevention measures are needed on 525,000 acres of farm land and 106,000 acres of range land by 2020 (Table 2-12). The cropland considered is presently used for crops and only incidental areas are expected to represent new lands to be used for farming purposes.

The present cost-price squeeze is forcing rapid changes in agriculture. Many farms are operating on a marginal basis in growing wetness-tolerant crops because of the limitations of the soil conditions. There is an awareness of the need to intensify and diversify production which will depend on better soil moisture conditions.

Irrigation is needed on much of the cropland to further modify the ability of the soil to grow crops and shift cropping patterns to meet market needs. The installation of irrigation to meet seasonal shortages of water will follow for the most part the installation of some degree of drainage improvement. Continued expansion of irrigation, in turn, may necessitate installation of drainage improvements. Much irrigation will continue to be an individual enterprise from ground and surface waters but project development of irrigation will assume greater impor-

1 Detailed explanations of measures recommended for conditions in each Basin are available through local soil and water conservation districts.

tance with time. Irrigation will be needed on 396,000 acres by 2020 (see Table 2-12).

Most of the drainage and irrigation improvements now in the Puget Sound Area are installed and maintained on private farms as a result of individual enterprise responding to economic opportunity. This will continue to be the situation but at a diminishing rate. To a great extent, advantage has now been taken of the more apparent physical opportunities for improvement of drainage. In future years, a larger proportion of drainage improvements will be contingent on the prior installation of group projects for reduction of floodwater damage and hazard; and for providing improved drainage outlets serving groups of farm units. Installation of projects for reduction of hazard, and for providing physical outlets for drainage will stimulate the rate of on-farm drainage improvement.

The diversity and scattering of individual farm improvements make it difficult to accurately estimate the rate of installation of drainage measures at any point in time. It is estimated, on the basis of local observations, that the present average annual rate of drainage improvement will need to be tripled by 1980, and that this increase will be possible only with implementation of projects for flood damage reduction and group drainage. The early action projects described in this Appendix (Table 2-20) will supply a major part of the opportunity (189,519 acres) for meeting the 1980 needs shown in Table 2-12 as 216,700 acres. The remaining needs (27,181 acres by 1980) can be met by individual improvements without specific project action.[1]

Irrigation has been, and will remain, largely an individual choice for the farm manager but is not likely to become a highly attractive management opportunity until more pressing problems affecting production efficiency are resolved. Irrigation as a management device will become more attractive as flood prevention and drainage improvements are assured. Most irrigation will be installed through individual management decisions resulting from economic opportunity. In a similar way, projects deemed feasible for construction after 1980 will provide opportunities to develop needed amounts of production efficiency improvements.

[1] **Refer to Appendix V, Water-Related Land Resources, Chapter 2, Agriculture, for benefits to be expected from drainage.**

## Forest Lands

The major influences affecting land stability and water conditions in forest lands have been identified as harvesting of trees, road construction, management for watershed protection, occupancy, natural disasters, and recreation.

**Roads and Trails**—One of the principal needs of forest lands at the present time is access. About five miles of permanent road and fifteen miles of temporary road are required for managing and harvesting one square mile of forest land. Temporary roads are closed following completion of the use for which they were built but require periodic reopening as management needs warrant. Portions of this access system are also utilized in recreation and forest management.

Construction of roads causes many water quality problems in forested areas. Treatment of these disturbed areas requires more intensive mulching, fertilizing, and planting of disturbed areas, as well as improved management in road location to avoid unstable soil areas. Improved bridges, water bars, and land stabilization measures will be required. Waterways and streams are critical areas, and it will become necessary to keep these areas clear of debris and other waste.

**Logging**—in future years will continue to be a potential source of sediment and debris. Measures to alleviate these problems include adequate reconnaissance, unit layout, and selection of suitable logging methods. Following logging, measures for rehabilitation of the disturbed areas should be utilized.

Table 2-11 projects by planning periods the number of miles of road developments, and the number of acres to be logged.

**Natural Disasters**—Fires, floods, windstorms, disease, and insect damage affect the timber cover and thus are related to the watershed condition. Fire is sometimes caused by man and this hazard may increase with greater recreational use of forest lands. This will require more management of access roads and fire detection. Windstorms and other types of disasters will create management problems also.

**Forest Management**—Most of the needs can be identified as related to management. The need for management to assure a supply of high quality water, or for other uses of the forested area, varies with each watershed. Many of these specific needs will become apparent only in future years. Estimates of needs, therefore, and means to satisfy needs, can be determined only on the basis of averages.

TABLE 2-11. Projected forest land road development and cutting, by planning periods

| Planning Period | Forest Roads Permanent (mi.) | Temporary (mi.) | Total (mi.) | Forests Logged Harvest Cuts (acres) | Intermed Cuts (acres) | Total (acres) |
|---|---|---|---|---|---|---|
| 1965-1980 | 9,300 | 36,100 | 45,400 | 885,100 | 567,900 | 1,453,000 |
| 1980-2000 | 11,300 | 51,500 | 62,800 | 1,055,600 | 1,446,700 | 2,502,300 |
| 2000-2020 | 12,100 | 90,500 | 102,600 | 1,004,000 | 1,922,400 | 2,926,400 |
| Total | 32,700 | 178,100 | 210,800 | 2,944,700 | 3,937,00J | 6,881,700 |

Good management may include irrigation and drainage of selected areas. Most such improvements will be needed on suitable lands of less than 30 percent slope.

An estimated 6,693,000 acres of forested lands will be in need of watershed rehabilitation and protection by 2020. Irrigation and drainage needs are not known but soil studies have shown that about 635,000 acres of forest lands are potentially irrigable. These needs, or potential needs, are based on the expected demand for increased production from less land (see Appendix VI, Economic Environment).

The management of national forests is frequently summarized in four categories: administration, protection, restoration, and water yield improvement. The first three categories are estimated to be currently funded at about two-thirds of the total needed, while water yield improvement currently receives virtually no funding. The entire United States Forest Service program for the early action period is therefore funded at about 60 percent of the total needed.

This information covers only national forest lands and the need for similar work on other forest land is assumed to be comparable to that on national forests. Current expenditures range from about 60 percent of the needs for certain public and large private owners to almost zero percent for some small private ownerships. The total expenditure is probably less than 40 percent of the need. This, of course, reflects management intent as well as available funding.

## OTHER NEEDS

### Recreation

The demand for recreation in the Puget Sound Area is expected to increase seven times between the years 1960 and 2020. To satisfy the 2020 demands, the development of an estimated 40,000 acres of forest and other lands for campgrounds, picnic grounds, and like facilities, is estimated. Some places will require additional practices, such as rotation of recreational areas. Measures needed for soil and water protection in recreational areas will include the stabilization of disturbed soil and provision for adequate sewage and garbage disposal.

### Beach Management

Many beach areas are valuable resources as habitats for marine life and as recreational sites. Beach features frequently provide opportunities for small boat moorages and other unique features.

Management of localized beach areas by the use of structural measures can, variously, stabilize the accumulation of sediment, encourage accretion, or induce removal. The use of structures in this way is not widespread in the Area and requires careful and detailed study of objectives, site characteristics, and use of structures that are inherently expensive to construct and maintain. Since such work modifies the natural manner of disposition of beach sediments, structures aimed at increasing beach accumulations at one point may result in removing material from some nearby depository.

The Puget Sound Area has over 2,000 miles of coastline and future stabilization of selected areas may justify greater construction for beach management. The extent and need for such work will require a future study to locate and evaluate needs for restoration, protection, or development of specific sites.

### Shorelands

Puget Sound shorelands, as well as the margins of many natural and artificial lakes, have increasing value as homesites, recreational areas, and for other uses. Many of these shores require rehabilitation and

treatment to prevent loss of land and other property, to preserve unique values, and to lessen damages to the contiguous water resource.

### Fish and Wildlife Habitat

Fish and wildlife resources usually share the use of the land and water of watersheds with other purposes. Measures for rehabilitation and protection of watershed lands are needed to protect and enhance these values. In many cases, management objectives need better definition. Specialized resource management practices may be required in watersheds where enhancement of these resources is a specific part of management objectives.

### Pollution Hazard Reduction

Many pollutants are carried by sediments and liquid flows from land areas. Need for reduction of this hazard will increase with population and with increased dependency on high water quality. Principal needs will be for improved land management, including flood prevention, low flow augmentation of selected streams, drainage, and watershed protection.

***Low Flow Augmentation of Streams***–The climatic pattern of the lowland area is conducive to greatly diminished flow of streams during summer months. In some streams this low flow denies the Area of considerable potential benefits in recreation, fish and wildlife habitat, and water quality. Land treatment and structural measures are needed to provide specific benefits. Often the need is for formulation of management objectives prior to planning.

**Streambank Stabilization**–Streambank stabilization is important to reduce land loss, property damage, and sediment delivery and to improve stream quality. Over 1,000 miles of streambank are estimated to require stabilization.

**Needs for Vector Control**–Miscellaneous needs for drainage, seepage control, and similar activities near structures and in areas requiring drainage are noted for the purpose of control of vectors associated with management of water and land resources. The needs for vector control include appraisal and evaluation of potential conditions.

**Water Yield Improvement**–The need for study of specific locations where water yield can be improved is recognized. Improvements for this purpose are not anticipated prior to 1980. Specific small areas for pilot operation and study prior to 1980 may be advisable.

**Research and Other Studies**–Needs for soil surveys, beach erosion surveys, sediment monitoring and study, are recognized, together with continuation and acceleration of research associated with agriculture, and the physical sciences related to agriculture, under Area conditions. Certain needs for policy clarification and legislation are also noted. These matters are discussed more fully under Means to Satisfy Needs.

## SUMMARY OF NEEDS

Determination of needs in the broad categories of floodwater damage reduction, watershed rehabilitation and protection, agricultural water management, and urban drainage benefit most purposes of management for multiple use of watershed lands. These measures also serve to protect and enhance fish and wildlife habitat, recreation sites, and water quality, and many other public and private purposes of management.

The present and future needs for watershed management in the Puget Sound Area are summarized in Tables 2-12 and 2-12A. This compilation shows, by types of land use, the number of acres on which measures are or will be needed for floodwater prevention, watershed protection and rehabilitation, drainage improvement, and irrigation development if the land is to continue safely in the use indicated. This generalization does not take into account quantitatively many other potential purposes, such as improvement of water quality, recreation sites, or fish and wildlife habitat, which may be among the features of specific projects.

## TABLE 2-12. Present and future needs for watershed management[1]

| Land Use & Year | Floodwater Prevention[2,3] (acres) | Watershed Protection & Rehabilitation[3,4] (acres) | Drainage Improvement[3] (acres) | Irrigation Development[3] (acres) |
|---|---|---|---|---|
| **Cropland** | | | | |
| 1980 | 454,400[5] | 659,000 | 216,700 | 183,200 |
| 2000 | 454,400 | 644,400 | 361,600 | 245,700 |
| 2020 | 454,400 | 631,300 | 482,100 | 396,000 |
| **Intensive Land Use** | | | | |
| 1980 | 101,800 | 731,400 | 731,400 | NA[6] |
| 2000 | 101,800 | 799,400 | 799,400 | NA |
| 2020 | 101,800 | 1,040,200 | 1,040,200 | NA |
| **Forest Land[7]** | | | | |
| 1980 | NA | 6,979,300 | NA | NA |
| 2000 | NA | 6,927,000 | NA | NA |
| 2020 | NA | 6,693,000 | NA | 634,900[8] |
| **Unclassified Uses** | | | | |
| 1980 | NA | 34,700 | NA | NA |
| 2000 | NA | 33,600 | NA | NA |
| 2020 | NA | 39,700 | NA | NA |

1 Figures (rounded) are from unadjusted measurements of Cooperative Soil Survey maps and aerial photographs, made in 1966 for the Puget Sound Area study.

2 Includes areas subject to overbank flooding of main streams.

3 Needed for full agricultural development. (See Appendix V, Water-Related Land Resources, Chapter 2, Agriculture).

4 Includes 106,300 acres of range land.

5 Includes 1,200 acres of land in transition.

6 Not available; meaning either not computed or not applicable.

7 Includes some non-forested land associated with forested areas.

8 Potentially irrigable land as shown in Appendix V, Water-Related Land Resources, Chapter 3, Forestry.

## TABLE 2-12A. Area of watershed management needs in thousands of acres by basins, Puget Sound Area[1]

| | Present to 1980 | | | | | 1980 to 2000 | | | | | 2000 to 2020 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Basin | Flood Prevention[2] | Watershed Protection & Rehabilitation | Drainage Improvement (Cropland) | Drainage Improvement (Urban) | Irrigation Development | Flood Prevention[2] | Watershed Protection & Rehabilitation | Drainage Improvement (Cropland) | Drainage Improvement (Urban) | Irrigation Development | Flood Prevention[2] | Watershed Protection & Rehabilitation | Drainage Improvement (Cropland) | Drainage Improvement (Urban) | Irrigation Development |
| Nooksack-Sumas | 135.1 | 792.2 | 55.4 | 33.6 | 60.0 | 135.1 | 792.2 | 92.3 | 33.6 | 80.0 | 135.1 | 792.2 | 123.1 | 33.6 | 115.0 |
| Skagit-Samish | 155.4 | 1,912.6 | 49.0 | 36.9 | 40.0 | 155.4 | 1,912.6 | 81.7 | 36.9 | 60.0 | 155.4 | 1,912.6 | 108.9 | 36.9 | 95.0 |
| Stillaguamish | 34.8 | 433.6 | 13.5 | 12.6 | 11.7 | 34.8 | 433.6 | 22.6 | 12.6 | 16.8 | 34.8 | 433.6 | 30.1 | 13.0 | 30.0 |
| Whidbey-Camano | 25.6 | 132.9 | 8.6 | 23.4 | 3.5 | 25.6 | 132.9 | 14.4 | 23.4 | 5.0 | 25.6 | 132.9 | 19.2 | 23.4 | 10.0 |
| Snohomish | 93.4 | 1,194.6 | 25.7 | 65.7 | 24.0 | 93.4 | 1,194.6 | 42.9 | 81.0 | 30.0 | 93.4 | 1,194.6 | 57.2 | 130.1 | 48.0 |
| Cedar | 27.2 | 363.9 | 3.2 | 196.0 | 2.0 | 27.2 | 363.9 | 5.4 | 236.2 | 3.0 | 27.2 | 363.9 | 7.2 | 303.5 | 6.0 |
| Green | 36.7 | 340.2 | 7.4 | 68.9 | 5.0 | 36.7 | 340.2 | 12.4 | 81.1 | 7.0 | 36.7 | 340.2 | 16.5 | 130.2 | 14.0 |
| Puyallup | 66.2 | 759.0 | 12.0 | 123.2 | 8.0 | 66.2 | 759.0 | 19.9 | 123.6 | 10.0 | 66.2 | 759.0 | 26.6 | 198.5 | 25.0 |
| Nisqually | 36.5 | 454.8 | 3.6 | 11.8 | 4.0 | 36.5 | 454.8 | 6.0 | 11.8 | 5.0 | 36.5 | 454.8 | 8.0 | 11.8 | 7.7 |
| Deschutes | 31.9 | 180.8 | 1.7 | 28.0 | 2.5 | 31.9 | 180.8 | 3.0 | 28.0 | 3.0 | 31.9 | 180.8 | 3.9 | 28.0 | 4.3 |
| West Sound | 71.0 | 1,281.4 | 17.1 | 108.4 | 5.0 | 71.0 | 1,281.4 | 28.6 | 108.4 | 7.0 | 71.0 | 1,281.4 | 38.1 | 108.4 | 15.0 |
| Elwha-Dungeness | 15.9 | 446.6 | 9.6 | 11.0 | 17.0 | 15.9 | 446.6 | 16.1 | 11.0 | 18.0 | 15.9 | 446.6 | 21.4 | 11.0 | 22.0 |
| San Juan | 17.3 | 111.6 | 9.9 | 11.9 | .5 | 17.3 | 111.6 | 16.4 | 11.9 | 1.0 | 17.3 | 111.6 | 21.9 | 11.9 | 4.0 |
| Total | 747.0 | 8,404.2 | 216.7 | 731.4 | 183.2 | 747.0 | 8,404.2 | 361.7 | 799.5 | 245.8 | 747.0 | 8,404.2 | 482.1 | 1,040.3 | 396.0 |

1 Unadjusted measurements for Puget Sound Area Study.

2 Included in this total are 191,000 acres of forest land that floods. No project works of improvement are expected while in forest.

# MEANS TO SATISFY NEEDS

Development of the land and water resources to satisfy the needs of the people is accomplished in three ways: (1) by individual development; (2) by community or group activity; and (3) through a program and project type of assistance to individuals, groups, or communities under legislative authority. The prime mover of any project or program is the individual, or group of individuals, interested in accomplishing a preconceived goal.

This section of Appendix XIV deals with what is recommended as the "means" or methods of accomplishing the goals. The concern here is with investments in watershed management and conservation. The public has an interest in such measures as they influence the environment for many social and economic values. These values depend on adequate stewardship of the natural resources. This portion of the Appendix, in effect, presents a plan for development and management of the land and water resources of the Puget Sound Study Area under conditions of sustained use to best satisfy the needs and wants of an expected population of 6.8 million in the Area by the year 2020. The means to be used in accomplishing the plan are discussed under several categories:

1. Legislative and policy clarification and implementation to furnish additional guidance reflecting the public interest in production and environmental quality, and in overcoming institutional obstacles in the interests of efficiency and clarification of objectives.

2. Additional study and research on physical, social, and economic factors generally having long-term but not fully evaluated effects on the public welfare. Encouragement of formal technical education in resource management to assure a supply of competent resource planners; and continuing and more adequate dissemination of information needed for guidance of the public to improve general awareness of environmental and production matters that are increasing in importance in the Area.

3. Continuation and acceleration of on-going programs aimed at private and public development and improvement of resources of land and water without accompanying degradation, and reflecting the public's interest in the use of resources by incentives based on full consideration of present and future productive and environmental qualities. Early action and other projects are presented as formalized portions of such programs where group action is needed to accelerate the work, and where feasible.

4. Projects and programs of various agencies are considered and related to needs of the Area. Additional emphasis is given to United States Department of Agriculture programs not presented elsewhere, and to coordination of USDA programs with those of other agencies of the State and Federal Governments in an early action program to achieve goals for the Area.

# PROGRAM OF ACCOMPLISHMENT

Land in the Puget Sound Area is generally well protected from accelerated deterioration at the present time. This is a result of rapid growth of vegetation characteristic of the Area, assisted by reasonably good management under present use. State and Federal agencies actively assist landowners in management problems and in protection against natural disasters.[1] The present level of management thus provides fairly good protection under present levels of use but will not be adequate for more intensive uses in the future, and denies adequate lead time for projects to become fully operative to meet future needs. Careful choice of land for various uses and full implementation of measures for rehabilitation, protection, and development is required.

About 85 percent of the watershed lands of the Puget Sound Area presently are forested or in crops. This relatively high percentage of open-use land is

[1] Appendix II, Political and Legislative Environment.

expected to decrease in future years to accommodate urban growth; however, the plan of land use advanced in Appendix V, Water-Related Land Resources, Chapter 2, Agriculture, and Chapter 3, Forestry, is to retain and develop certain kinds and amounts of land best adapted for productive uses.

Despite the reduction in the areas projected for cropland and forest uses, better management of the best agricultural land will enable production in the Puget Sound Area to increase with time at a rate which will provide the share of national production of food and fiber in 2020 that is projected in Appendix IV. This share is based on the estimated increase in population nationally rather than on the greater increase projected for the Area, and indicates the Area must increase the percentage imported of some agricultural products above present levels. The means of protecting, managing, and improving watershed lands for productive urban and environmental purposes is discussed herein.

This Appendix, under Present Status and Potential, gives the present condition of related lands in the Area and examines the potential of the land resource for development to meet various uses, including increased production. It also sets forth the kinds and amounts of protective measures and development required to accommodate production goals, as well as similar measures and spatial requirements for other purposes, including an average population density of six persons per acre in areas to be developed for urban use.

It appears that with a planned program of resource use and development, the Area has adequate land and water resources to satisfy the needs. Certain present trends in unplanned urban use of better agricultural lands, if projected, would in time deplete the cropland base. Since one purpose of planning is to reverse adverse trends, certain policy constraints and incentives are recommended to reserve for farm use approximately 6 percent of the Area. This will be the best agricultural land which is located mainly in the flood plains of rivers and tributary streams.

The plan for development and use of the land and water resources of the Puget Sound Area consists of related programs and projects. A program is a plan of procedure to accomplish the desired management, construction projects, education, information, and financial assistance has been included. A project is a formal endeavor within a program to accomplish a segment of the overall program. The Puget Sound Area will require legislation to provide moderate land use regulation; appropriations for technical assistance programs; appropriations for assistance in needed structural works of improvement; other incentives; and information and assistance.

## LEGISLATION AND POLICY CLARIFICATION

The expectation of ever-increasing population requires that the land be guarded from improper use and protected with the technology gained through practice and research. In 1968, there were approximately two and one-half acres of arable land per capita in the United States. This is expected to drop to one and one-quarter acres per person by 2020 as a result of increased population. With nearly three-fourths of the continental United States comprised of non-arable land, the selection of suitable land for urban use need not encroach indiscriminately on the arable land nationally, and this is true for the Puget Sound Area as well.

As means to aid in achieving the desired goals, the following are selected items that appear to need implementation or improvement in their political and legislative aspects. The list is not intended to be comprehensive.

### Land Use Regulation and Incentives

To aid owners and developers select proper development sites, legislation is needed to allow competent technicians to determine the capability and suitability of the land for use, and to provide the State with objective means to legally designate the use for future generations. Within a free economy, this restriction of ownership rights must provide compensation and other incentives. Legislation is also needed as a means of fixing final authority for overall planning control in a competent, non-competitive agency such as the State, under which detailed planning can function in a way best suited to the public good.

**Land Use Regulatory Measures**—Effective and intelligent application of firm regulatory measures is needed in the public interest for a number of reasons:

With such regulation, developments can be zoned out of, or controlled in, flood susceptible areas to avoid compounding the cost of flood protection. Developments allowable in such areas can be limited

to agriculture, or other open or semi-open use, so that damageable values are kept within reasonable limits.

Areas of scarce but valuable land needed for production of food or fiber can be protected, safeguarding against urban sprawl or activities having widespread or long-range undesirable effects on the environment. Residential or commercial development can be restricted to sites where sanitary sewers are available.

Critical areas of watersheds requiring protection for the benefit of downstream values can be delineated and protected. Benefits would include stream regimen protection, and protection from silt damage and other deterioration. The State can assist counties and municipalities in establishment and enforcement of zoning.

**Preferential Taxation**–and other incentives can be used, together with land use regulation, to encourage permanent dedication of land to agriculture or other open use in the public interest in areas subject to urban development. Enabling legislation was passed by the State of Washington Legislature in 1968 permitting taxes to be based on use rather than on speculative value.

### Critical Area Treatment and Development

The land surface and its condition is a vital link in the hydrologic cycle. The physical, ecological, and biological condition of variable areas of each watershed may be considered vital to the stability of the soil mantle, prevention of sediment damage, and prevention of pollution, with preservation of tolerable stream regimens. In some cases, critical areas of watersheds must be protected, and possibly treated, in the public interest regardless of present ownership. To this extent the public should have the means of acquiring, and treating or protecting critical areas. Other powers should include the supervision of land use, intensity of use, and application of protective measures or treatment required. Examples might include fire protection; prevention or regulation of logging, roadbuilding, and urban developments; installation and maintenance of treatment measures, such as improvement of waterflow channels, reforestation, construction of terraces and outlets, water impoundments, and water spreading devices. Some legislation or policy revision may be required as a means of implementing these needs and provide for compensation to individual owners, where necessary, for damages.

**Pollution Control**–Current methods of disposing wastes into the ground, the atmosphere, or the waters will require careful analysis and supervision. Waste products include not only complex variations of organic, chemical, and radioactive materials, but sediments from watershed and stream erosion. Care should be taken to distinguish between tolerable levels of geologic or semi-geologic erosion and accelerated erosion that is preventable by good watershed management and stream protection. Regulation should include activities producing inordinate amounts of sediment. The implementation of good management and preventive measures, including maintenance, will require regulation, and in some cases subsidy by public funds.

**Stream Improvement**–This may be taken as control of streams to prevent flooding and sediment damage, including pollution, as well as augmentation of low flows to prevent damage to fish, wildlife habitat, and aesthetic values. Much can be done to enhance the natural value of the streams in the public interest. In some cases, this work may require subsidy or compensation of individual owners, with active participation of State and Federal agencies.

### Coordination in Planning and Development

Numerous improvements are installed annually by various departments of the State and Federal Governments, as well as by private enterprise. Highways, powerlines, railways, pipelines, and many other improvements are currently being installed without the level of coordination that is desirable. Considerable excess cost presently results from conflicting or uncoordinated planning. Elements of some activities become competitive. Some of the lack of coordination in administration is the direct result of legal or policy barriers contained in enabling or funding legislation. These barriers will become more troublesome and costly as time goes on. A concerted effort should be made to "clean up" as many of these barriers as possible and to coordinate such efforts in the public interest.

**Funding Legislation**–Many of the improvements needed can best be administered by small local elements of government. Many elements of government, otherwise well fitted for the work, lack sufficient legal and financial ability to provide the development needed. There is a real need for non-Federal credit assistance, financial assistance, and grants-in-aid to many small improvement districts and other levels of government, including small municipalities and counties, for the installation and maintenance of improvements. The State could provide this assistance, including objective consultation and super-

vision, thus providing a degree of stability much needed for these developments.

Areas where help is principally needed are in securing rights-of-way, in coordinating works of development, and in adding features to small, single-purpose developments that benefit the general public. Help is needed also in controlling influences that are of an exploitive nature, such as urban sprawl, or that cause excessive and often indirect costs to the public.

**Right-of-Way Acquisition and Supervision**–In many small resource development projects, it is necessary to secure land rights and other rights needed for installation, construction, and maintenance of improvements. Presently, many of these rights must be secured by various legal improvement districts that do not have adequate size to provide needed legal, financial, and other technical resources. Often, a supervisor of a district is a neighbor or close associate of the owner of a land parcel that must be acquired by condemnation. The condition is often so awkward that it effectively prevents or delays needed improvements, resulting in a public disservice. It is believed much of the delay and cost of such matters could be alleviated by an adequate State agency which would provide objective judgment, adequate technical facilities, and adequate financial resources to extend credit and grants-in-aid as dictated by public need. Such extension of objective services would add greatly to the justice and dignity of proceedings and the stability required for acquiring and maintaining needed improvements.

**Improvement Districts**–State law appears to be unnecessarily cluttered with various forms of districts with overlapping jurisdictions and vague powers. The functions thus covered possibly could be better administered by a relatively few types of districts having comprehensive powers and vigorously supervised and audited by State authority.

## OTHER STUDIES AND SURVEYS

### Education, Information, and Research

There is a movement of rural populations to urban centers, with the result that large numbers of people are less aware of rural land and water problems but not less dependent on the resources involved. The trend away from intimate relationship with the land is exemplified in many ways, one of which is the general decline in relative numbers of secondary school graduates in scientific, and agricultural fields, and of specialists in physical and biological sciences related to natural resources.

Dependence of the public on natural resources is increasing, as shown not only by demands for production but in rapidly increasing demands for good hydrologic quality, improvements in water quality and yield, recreation, fish and wildlife habitat, and aesthetic and social values. Lands managed for multiple uses rather than for substantially a single use cost more in required management measures. The public can be expected to demand much more in terms of multiple uses of watersheds, and to share in these costs either through increased cost of food and fiber or through support costs. Demands of the public must be well formulated, made known, and accepted by the legislator and landowner before they can be properly implemented. Accomplishment can be attained only with complete dialogue and agreement, requiring the best elements of professional planning, research, and capital, combined with the experience and desires of the owner, in meeting private and public needs.

A program of information must be continued and expanded on two fronts; one program oriented to the city dweller to keep him informed of his responsibility in the use of the land and his dependence on the land base; and the other program to expand the dissemination of information to landowners on use and care of the land and on technological advances that will encourage good maintenance of the land resource through private enterprise.

Students in institutions of higher learning must be encouraged to enter the field of resource planning. In related agricultural sciences, the current national shortage of graduating students is between eight and ten thousand a year. Incentives must be provided so that students trained in the fundamentals of land use will continue to research problems in drainage, irrigation, forestry, plant breeding, water development, water quality, and water requirements. Research in economics is needed to determine cost sharing formulae for construction of works of improvement which will benefit the social community. The critical need for food and fiber production all over the world requires added research toward better management of the land resource.

Most aspects of watershed management require additional and continued study to develop new technology and to test and adapt new advances in technology into practical use; also to evaluate criteria for programs and projects in the light of changing times. Most of this study and evaluation is expected

to be accomplished under on-going Federal and State programs, continued and expanded as required by needs during ensuing years.

A few areas of study are identified in the following, but the list is not intended to be exhaustive.

### Sediment Study

A comprehensive program of study concerning the various rural and urban aspects of sediment production, sediment movement, and sediment impacts, including pollution in impoundments, stream channels and estuarine areas, should be undertaken. The work would involve a long-term program of measurement and evaluation, with projection into future conditions covering physical, economic, environmental, and ecological impacts of sediment. This study should be initiated before 1975 and preliminary reports prepared before 1980. The study should be a cooperative venture between the State of Washington, private interests, and the appropriate agencies of the Federal Government. The cost of the study is initially estimated to be $150,000 per year.

### Soil Surveys

National park lands and national forest lands have not been adequately surveyed. Early surveys on private lands do not have the intensity and comprehensiveness needed for making intensive development. There is a need to accelerate the making and improvement of the cooperative soil surveys. The estimated cost of these surveys, including publication, is $3 million. The work will require many years at the going rate of accomplishment and should be accelerated. It is recommended that the work be accomplished by 1980 at an average cost of $300,000 per year.

### Beach and Shore Erosion

A study of beach and shore erosion should be initiated and completed by 1980. This is considered to be about a 5-year study, estimated to cost $500,000. It would define present problem areas and project the needs to the year 2020.

Accurate costs of remedial measures to stabilize the beach erosion areas discussed in the Present Status and Needs sections have not been determined. Such an evaluation would require a detailed investigation over a period of time, including investigations of seasonal variations in conditions, tidal hydraulics, engineering, and economic feasibility.

An early action study program prior to 1980 is recommended for the purposes of: (1) determining all areas along the Puget Sound and adjacent waters shoreline where significant erosion occurs; (2) identifying those areas where erosion presents a serious problem because the rate of erosion, considered in conjunction with economic, industrial, recreational, agricultural, navigational, demographic, ecological, and other relevant factors, indicates that action to halt such erosion may be justified; (3) describing the most suitable type of remedial action for those areas that have a serious erosion problem; (4) providing preliminary cost estimates for such remedial action; and (5) recommending priorities among the serious problem areas for action to stop erosion. This program will provide for a 5-year study and include the following elements:

a. Public hearings to be held in different localities throughout the Area to determine major problem areas.

b. Reconnaissance of problem areas to determine the extent and rate of erosion at each area.

c. Other studies, including tidal hydraulics, foundations and materials, engineering, and economics performed as needed to determine the types of remedial action warranted and he estimated costs and benefits.

d. A report presenting the findings to be prepared at the end of the study.

This program would define problem areas requiring immediate attention and project the needs of other areas to the year 2020. For purposes of the Puget Sound Area Study, investment costs for rectification measures required between 1980 and 2000, and between 2000 and 2020 are estimated at $100 million for each period.

### Land Use and Treatment

Watershed lands require detailed planning, careful management, and regulation of use and treatment to preserve productive and environmental factors. The direct and indirect loss of such values through unplanned urban expansion or entrepreneurial ventures should be evaluated. Estimation of hitherto intangible values needs to be made, including values foregone. Full evaluation of all factors will require development of quantitative judgments beyond that generally in use at the present time. Certain elements of systems analysis should be developed and applied in evaluating total effects of changes in ecological and environmental aspects of

land. Evaluation of use by the public, and regulation when required, transcend purely local forms of government and should become the specific responsibility of the State. Costs of further study are not estimated but, by agreement, possibly can be shared between the State of Washington and appropriate agencies of the Federal Government. Such studies should be accomplished before 1980 and be re-evaluated at frequent intervals thereafter.

### Water Yield Improvement

Watersheds can be managed for specific purposes, including the improvement of water yield. Water yield improvement includes structural and vegetative measures to increase surface impoundment, subsurface storage, snowpack management, and modification of evapotranspiration. A study of general factors should be conducted to define present problems and identify project needs. A part of the study would be for the purpose of adapting basic research findings from other regions of the United States to specific Puget Sound conditions, and may include pilot operations. The other part of the study is to identify and evaluate specific streams or stream reaches where benefits from increased water yield and/or low flow improvement are sufficient to define areas for improvement. Portions of the study methods described under Land Use and Treatment may be applicable for this analysis. Few, if any, water yield improvement projects are anticipated to be found favorable before 1980; however, studies should be undertaken in the near future with preliminary findings by 1980, identifying areas for future improvement to the year 2020. Costs of the study are expected to be borne by existing Federal, State, and local programs.

### Production Studies

Studies related to efficient farming and forestry methods should be continued and accelerated since viable and stable private enterprise on lands devoted to these purposes is essential to maintenance of the environmental quality. Assistance on a continuing basis will be given in technical matters concerned with the impacts of changed land use and development of the environment. Costs are expected to be borne by cooperative State and Federal programs.

## STEWARDSHIP OF LAND AND WATER RESOURCES

Proper selection of land for specific uses is a major element in watershed protection. The protective and improvement practices discussed here are grouped into several broad categories: floodwater damage reduction, watershed rehabilitation and protection, and water management. Under these broad categories, there are often potential benefits for recreation sites, fish and wildlife habitat, improvement in water supply or quality, and environmental values. All practices play an interrelated part in the application of technological advances to be developed through future research.

The objective of planning is to insure protection of the land under expected or potential development. Practices and programs are expected to be implemented which will furnish means of protection against floodwater damage, erosion, and sedimentation. As the resource is protected, the development programs will be implemented to achieve the potential of the land for the specific use.

Land in public ownership is managed by the public policy and institutional restraints. The public interest is to improve and maintain these policies to preserve the environment. On national forest lands caretaking responsibilities must be continued and intensified to make full use of these lands which contain many economic and social values.

The future management of agricultural land is determined by the value of its production and this is difficult to determine for future years since it depends on products, markets, and available alternative uses. Croplands on flood plains are highly productive and respond to drainage, irrigation, and associated practices. Large amounts of drainage, irrigation, and streambank protective measures are expected to be installed. Flood prevention sufficient for agricultural use will be installed in future years. Terrace lands and other lands of good quality devoted to crops will be irrigated if water is available. Areas subject to wetness will be drained. Measures to prevent erosion and control runoff will be required. Public interest in private use will become an issue in public access, recreation, and aesthetic values of open lands. Urban and rural nonagricultural uses will

require withdrawals from agriculture of this type of land. Uplands are less suitable for cultivation because of lower production and higher maintenance costs. Demands for rural residences and recreation areas here are expected to be high. Mountainous and foothill lands are expected to remain largely in forest, with greater use for recreation and similar purposes. Better planning, a higher degree of social control, regulation of use and treatment of the land, and financial participation by the public will be required.

## FLOOD DAMAGE REDUCTION

Reduction of damage from floodwater and sediment is achieved by installation of land treatment measures and by structural works of improvement. The degree of protection required is governed by the damage likely to occur with protection. Where intense improvements and many people occupy hazardous areas, protection against events likely to recur more frequently than once in 100 years is the usual required minimum. Where land is in agricultural or other low intensity use, and the hazard to property or human life is low, floodwater damage must be prevented to the extent the hazard remaining does not materially exceed other risks before development investment becomes practical.

Approximately 747,000 acres in the Area require some degree of protection before full development as agricultural land or development for urban uses is deemed feasible. Most urban development on flood plain areas should be discouraged. Existing urban developments, and essential developments requiring occupancy of flood hazard lands, will, however, require high levels of protection. Flood plains contain the high quality agricultural land of the Area (comprising about six percent of the total land area) and should be retained in this use.

The flow of major streams is such that protection against overbank flooding can be provided only by flood control structural measures. Estimates are that 307,000 acres will receive additional levels of protection from overbank flooding by 2020. Proposals covering this type of protection are described in Appendix XII, Flood Control.

Flood prevention measures on tributary streams and at the watershed level (areas of 250,000 acres or less) are considered in more detail in the sections of this Appendix regarding individual basins. These measures are for the reduction of floodwater damages caused by abnormally high direct precipitation, stream overflow, or floods aggravated by wind and tidal effects. Flood prevention measures consist of land treatment to retard runoff to the highest degree practical, combined with structural measures that result in floodwater damage reduction. Such measures are often included in small watershed projects that are multi-purpose in nature and provide floodwater damage reduction in addition to water management and other benefits. Twenty-five projects containing flood prevention measures are feasible for installation by 1980 as a part of the early action program. These proposed projects will provide flood damage reduction benefits to 188,000 acres, in addition to other benefits, and are summarized in Table 2-20.

Flood prevention measures and flood control measures are often complementary and frequently both kinds of improvements are required to achieve full potential benefits from damage reduction and development. Federal policy requiring coordination between projects for flood prevention and flood control benefits is defined by Federal agency directives and is best achieved at the project level by contemporary authorization and simultaneous or timely installation of interrelated structural features.

The early action program contains projects for installation before 1980 in recognition of a rapidly increasing population creating needs in the Area approaching an emergency situation. Planning at the project level involves concerned agencies of the Federal Government and the State of Washington. In order that project planning and timely installation of interrelated features of these projects proceed with maximum benefits, the Secretary of Agriculture may elect to request immediate Area-wide planning authorization by Congress of the watershed projects contained in the early action program of the Department of Agriculture.

## WATERSHED PROTECTION AND REHABILITATION

Provision for establishing and maintaining watershed protection and rehabilitation measures on 8,404,400 acres of land is the responsibility, primarily, of the landowners or, in the case of publicly-owned lands, of the Federal or State agency charged with management of the lands. The owner or manager of cropland is expected to keep it in protective cover during hazardous seasons and to apply such practices as cover cropping, grass and legume seeding, etc. to the land under his manage-

ment. The United States Department of Agriculture, through its agencies, furnishes technical and financial assistance to landowners and managers who request aid in establishing some of these practices. Land management agencies of the Federal Government are expected to manage lands under their supervision in accordance with accepted practices of conservation for continued use. Continuation or expansion of on-going programs will accomplish this.

This plan provides that most of the best cropland presently used for farming will remain in this use; and that, by use of density control, only a small amount of additional land will be needed for urban or other nonagricultural purposes. Only about 6 percent of the land in the Puget Sound Area is planned for farming, and about 15 percent for urban and other uses with a density of six persons per acre. Since large areas of land are suitable for urban development, there should be little conflict on the basis of suitability of land for use.

Due to the dominance of forage production as a major part of farm production, much of the farm land is expected to remain under excellent cover. Care must be used to protect farm lands during the winter season. This usually requires establishment of winter cover crops on lands used for production of intertilled crops. Establishment of cover crops is often materially assisted by drainage and irrigation practices.

Where sloping land must be used for row crops, planting and cultivation should be accomplished following the contour of the land. Critical sediment producing areas should remain in permanent cover with agronomic and other practices to retard the outflow of water and transport of sediment. In particularly critical areas, permanent graded terraces and outlet channels may assist in removing excess water and promoting stability. Rotation grazing, good cultural practices, fertilizers, and use of deep rooted vegetative species encourage infiltration and work together to reduce sediment production. Typical measures are shown in Table 2-18.

Much of the land presently classed as "rural and nonfarm" will be developed for urban living. Practices to be applied are for the prevention of damage to the land in the process of urbanization, and for recreation improvements. Land leveling, proper drainage, proper water disposal, grade stabilization structures, recreation area woodland improvement by thinning and pruning, recreation land grading and shaping, and recreation trail and walkway construction, are and will be installed under this plan. The physical effects will be to prevent sediment movement from the areas and enhance them for public use.

Local planning authorities may obtain advice from soil and water conservation district personnel on conservation measures needed on tracts being sold for residential housing or industrial use. This will be an important phase of technical assistance provided under this program.

Forested lands of the Puget Sound Area comprise the largest acreage with high erosion and sediment production potential, and are also the source of approximately three-fourths of the available surface waters. The quantity and quality of these waters is influenced to a large extent by the hydrologic condition of the source watersheds. Problems involving water quantities and quality are often the result of conditions prevailing in the source areas. Typical protective measures are shown in Table 2-19.

As noted previously, there are 2,015,300 acres of land in Capability Classes VI, VII, and VIII with a severe or very severe erosion hazard, and 1,352,400 acres in Classes II through IV with a moderate erosion hazard. In addition, 3,490,000 acres under Federal administration are estimated to have a severe to very severe erosion potential. While the potential for erosion is very great in the Area, severe erosion has been prevented in the past by generally excellent cover.

When the protective vegetative cover is disturbed, the result is a critical erosion area that yields large quantities of sediment. Expected timber harvest, road construction, and urban development will disturb this cover on 138,000 acres each year. Thus, the critical erosion area at any point in time consists of newly harvested forest lands; cropland without winter cover crops; and land annually disturbed by development activity, plus lands damaged by natural events (wildfire, shore and streambank erosion, flooding, and sedimentation); and land recovering from disturbances in previous years. These are the lands requiring rehabilitation measures. All other watershed lands require protective measures to reduce danger of erosion and to maintain essential hydrologic conditions.

Of the 1,600 acre-feet of sediment estimated to be carried by streams of the Area, forest land is estimated to represent 63 percent of the source; cropland, 9 percent; range land, 2 percent; and other

lands, 26 percent.[1] Urban development of various kinds represents a large part of the "other" lands. The estimated 1,600 acre-feet of sediment yield represents only a portion of the gross erosion, much of which represents land deterioration in areas where sediment is not carried by streamflow.

One of the principal sources of sedimentation is road construction. The precautionary measures to be installed in the construction of roads vary with the relative stability of the landscape through which the roads pass. Generally, good road design provides for: (1) recognition and avoidance, where possible, of unstable soils or slopes; (2) utilization of the most favorable terrain for road location, away from live streams wherever possible; (3) proper placement of spoil materials, either within the roadbed or as waste; (4) stabilization and vegetation of cut and fill areas; (5) adequate drainage of surface waters; and (6) adequate live stream crossings which conform as nearly as possible to the original configuration of the streambed. Where roads are well designed and constructed, the level of erosion will be kept within acceptable limits.

Logging operations, also, may be a major source of sediment and debris. For optimum management of watershed resources, timber harvesting plans need to be tailored to fit the requirements of each area. Such plans should consider the following points:

a. Cutting unit layout boundaries should be placed in the most favorable locations with respect to terrain. Yarding of logs in or through streambeds should be avoided. Following logging, streams should be cleared of any unavoidable logging debris. Log landings should be located at points that will cause the least soil disturbance in the yarding process.

b. Tractor logging on nearly level ground or gentle slopes is normally suitable; however, cable systems are better adapted to logging on slopes over 30 percent. Very steep topography and other critical soil conditions may require the use of more sophisticated cable systems, such as the Skagit, Wyssen, or the recently developed balloon system which lifts the logs free of the ground during much of the yarding process.

c. Temporary roads, skid trails, and firebreaks should be rehabilitated as soon as possible after logging to restore the vegetative cover and control erosion. Useful treatment measures include planting, seeding, mulching, scarifying, and the installation of water bars.

d. Exposed soil areas resulting from logging or slash disposal require stabilization to control undue soil loss and gullying. Treatment measures include planting, seeding, mulching, and contour furrowing.

Wildfires pose a serious threat to all forest resources, including timber and water. Fire consumes or kills most of the vegetation, burns away the duff and litter cover, and thus exposes large areas of mineral soil. Management can do much toward reducing fire losses through planned fire prevention programs, including the reduction of logging slash, or other hazardous fuels; and employment of extra precautionary measures, such as closing forest areas during periods of extreme fire danger. In addition, an adequate suppression organization is required to control and confine the size of the fires to the lowest possible limits (Table 2-19).

## DRAINAGE

The means to be used in developing the required soil-moisture relationships necessary to achieve the fullest potential for the land use selected are many and varied. Methods of attaining the drainage goals for agricultural and urban uses of the land are given here. To accomplish the goals, it will be necessary for individuals and groups to cooperate with State and Federal agencies in establishing works of improvement to this end.

### Agricultural Drainage

A large portion of the cropland in the Puget Sound Area is used for the production of high quality perennial grass crops for forage. These crops generally require a high degree of drainage for best production during the growing season, and some drainage during winter months, so that sensitive grass species will not be lost. Because of the requirement for some winter drainage, and because of a relatively deep rooting habit of some desirable species, the crop requires a relatively high degree of drainage improvement measures, often exceeding the requirements for intertilled crops. The drainage improvement required for high-quality grass crops is used herein as representative. The use of this degree of drainage improvement will allow some latitude in meeting requirements of other crops.

Optimum drainage improvement of land used for forage production has other benefits. These

[1] From Columbia-North Pacific River Basin Type I Study, 1969.

include: (1) reduction of damage from trampling by livestock when pasturing wet ground; (2) inducing deep rooting habits in the plants, causing reduction of unfavorable reaction to drought and hot weather; (3) greater production; (4) greater resistance to plant diseases; and (5) promoting conditions that contribute to improved health of livestock.

Technical guides, prepared by the Soil Conservation Service for the Puget Sound Area, classify the installation of drainage improvements for various soils into sixteen major groups. Each group refers to the principal operations, such as spacing, required to install drainage improvements under certain soil conditions. Descriptions of these drainage groups follow:

**Group 1**–Deep, moderately well, and imperfectly drained soils with silt loam, light clay loam or loam surface soils and clay loam or silty clay loam subsoils.

**Group 2**–Moderately deep, imperfectly drained loam or silt loam surface soils and subsoils overlying slowly permeable cemented glacial till at depths of 20-36 inches.

**Group 3**–Deep, poorly drained, and very poorly drained muck and peat soils.

**Group 4**–Deep, poorly drained soils with silty clay loam, silt loam, fine sandy loam, or loamy fine sand surfaces and silty clay loam subsoils overlying peat at dominant depths of 20-36 inches.

**Group 5**–Moderately deep, poorly drained soils with clay loam, silty loam, silty clay loam surface soils and moderately slow to slowly permeable silty clay or clay subsoils.

**Group 6**–Moderately deep, imperfectly, and poorly drained soils with silty clay loam, clay loam, loam, silt loam, and sandy loam surfaces and slowly permeable or moderately slowly permeable silty clay loam or clay loam subsoils.

**Group 7**–Moderately deep, moderately well, and imperfectly drained loam, silt loam, and sandy loam soils with medium textured subsoils overlying slowly permeable cemented glacial till, mud flow, hard silty clay loam or soft sandstone material at depths of 20-36 inches.

**Group 8**–Moderately deep and shallow, poorly drained soils with loam, silt loam, or sandy loam surfaces and subsoils overlying iron cemented (Orterde) hardpan at dominant depths of 8-26 inches.

**Group 9**–Moderately deep, poorly drained soils with silt loam, loam, and clay loam surfaces and very slowly permeable clay or silty clay subsoils at dominant depths of 20-36 inches.

**Group 10**–Moderately deep, imperfectly drained soils with loam, silt loam, and clay loam surfaces (including gravelly textures) and clay loam subsoils overlying slowly permeable clay till at dominant depths of 20-36 inches.

**Group 11**–Moderately deep and shallow, moderately well drained soils with sandy loam, gravelly loam, loam, and clay loam surfaces and subsoils overlying cemented glacial till at dominant depths of 12-36 inches.

**Group 12**–Moderately shallow and shallow, poorly drained muck and peat soils overlying sand or clay at dominant depths of 12-36 inches.

**Group 13**–Moderately deep, poorly drained soils with loam and clay loam surfaces (including gravelly textures) overlying slowly permeable subsoils at dominant depths of 20-36 inches.

**Group 14**–Moderately deep and shallow, poorly drained soils with loam, silty clay loam, clay, and silty clay surfaces overlying very slowly permeable clay and silty clay subsoils at dominant depths of 12-36 inches.

**Group 15**–Moderately deep, poorly drained soils with sandy loam surfaces and subsoils, overlying slowly permeable iron cemented hardpan at dominant depths of 20-36 inches.

**Group 16**–Shallow to very deep, well drained, and somewhat excessively drained bottom land soils subject to overflow and sedimentation.

These sixteen drainage groups were combined on a basis of approximately average costs of drainage improvements for high-quality forage production into six groups for price estimating purposes, as shown in Table 2-13. These per acre costs were utilized in summarizing drainage costs by watersheds for the Area in Table 2-14.

**TABLE 2-13. Per acre and average annual on-farm costs of agricultural drainage[1]**

| Drainage Groups Combined | Price Group | Cost Per Acre | Average Annual Cost Per Acre |
|---|---|---|---|
| 1 and 12 | 1 | 230.70 | 16.76 |
| 2, 7, and 16 | 2 | 115.85 | 8.49 |
| 3, 4, and 5 | 3 | 348.73 | 25.34 |
| 6, 8, 9, and 11 | 4 | 132.00 | 9.59 |
| 10, and 13 | 5 | 198.00 | 14.38 |
| 14, and 15 | 6 | 70.00 | 5.09 |

[1] Based on 1967 prices, amortized at 6 percent for 30 years.

## TABLE 2-14. Summary of estimated drainage costs by basin and watershed (1967 price base)

| Map No. | Watersheds | Cropland drainage groups: Groups 1 & 12 | Groups 2, 7, & 16 | Groups 3, 4, & 5 | Groups 6,8,9, & 11 | Groups 10 & 13 | Groups 14 & 15 | Total | Weighted cost per acre | Total cost crop-land 1/ | Urban and rural non-farm | Cost per acre | Total urban and rural non-farm 2/ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | (acres) | (acres) | (acres) | (acres) | (acres) | (acres) | (acres) | (dollars) | (dollars) | (acres) | (dollars) | (dollars) |
| 0-29 | Lower West Slope Seattle | 39 | | 20 | | | | 59 | 270.71 | 15,972 | 15,906 | 1,350 | 21,473,100 |
| 0-34 | East Side Green River | 5,963 | 3,256 | 1,691 | 1,115 | | | 12,025 | 207.05 | 2,489,754 | 24,181 | 1,350 | 32,644,350 |
| 0-35 | West Side Green River | 6,228 | 800 | 1,139 | 492 | | | 8,659 | 230.01 | 1,991,627 | 14,557 | 1,350 | 19,651,950 |
| 0-36 | Lakota-Des Moines | | | 48 | 19 | | | 67 | 287.27 | 19,247 | 10,653 | 1,350 | 14,381,550 |
| 0-37 | Upper Green River | 277 | 3,923 | 515 | 100 | | | 4,815 | 147.70 | 711,180 | 3,554 | 1,350 | 4,797,900 |
| TOTAL | GREEN BASIN | 12,507 | 7,979 | 3,413 | 1,726 | | - | 25,625 | Av.204.01 | 5,227,780 | 68,851 | Av.1,350 | 92,948,850 |
| 7-1 | White River | 2,730 | 11,036 | 1,258 | 50 | | | 15,074 | 156.14 | 2,353,634 | 12,235 | 1,350 | 16,517,250 |
| 7-2 | Carbon River | 74 | 922 | 6 | 10 | | | 1,012 | 125.79 | 127,298 | 1,422 | 1,350 | 1,919,700 |
| 7-3 | Puyallup River | 3,803 | 6,700 | 186 | 284 | | | 10,973 | 160.02 | 1,755,899 | 22,083 | 1,350 | 29,812,050 |
| 7-4 | South Prairie Creek | 75 | 2,089 | 50 | 36 | | | 2,250 | 125.11 | 281,501 | 973 | 1,350 | 1,313,550 |
| 0-38 | Hylebos Creek | 819 | 79 | 165 | 195 | | | 1,258 | 223.67 | 281,375 | 7,303 | 1,350 | 9,859,050 |
| 0-39 | Wapato Creek | 1,412 | 130 | 20 | 137 | | | 1,699 | 215.34 | 365,867 | 3,859 | 1,350 | 5,209,650 |
| 0-40 | Fort Lewis-Tacoma | 366 | 231 | 200 | 209 | | | 1,006 | 207.29 | 208,531 | 75,300 | 1,350 | 101,655,000 |
| TOTAL | PUYALLUP BASIN | 9,279 | 21,187 | 1,885 | 921 | | | 33,272 | Av.161.52 | 5,374,105 | 123,175 | Av.1,350 | 166,286,250 |
| 0-41 | Muck Creek | 602 | 3,838 | 355 | 380 | | | 5,175 | 146.37 | 757,472 | 3,171 | 1,350 | 4,280,850 |
| 0-42 | Horn-Tanwax Creeks | 332 | 3,518 | 250 | 236 | | | 4,336 | 138.95 | 602,486 | 864 | 1,350 | 1,166,400 |
| 0-43 | Ohop Creek | 243 | 1,531 | 195 | 10 | | 14 | 1,993 | 152.40 | 303,728 | 790 | 1,350 | 1,066,500 |
| 0-44 | Mashel River | 38 | 412 | 90 | | | 20 | 560 | 159.43 | 89,283 | 768 | 1,350 | 1,036,800 |
| 0-45 | Nisqually River | 2,361 | 2,666 | 723 | 1,513 | 200 | 80 | 7,543 | 179.05 | 1,350,587 | 6,256 | 1,350 | 8,445,600 |
| TOTAL | NISQUALLY BASIN | 3,576 | 11,965 | 1,613 | 2,139 | 200 | 114 | 19,607 | Av.158.29 | 3,103,556 | 11,849 | Av.1,350 | 15,996,150 |
| 0-46 | Deschutes River | 1,012 | 180 | 683 | 380 | 60 | 40 | 2,355 | 236.66 | 557,344 | 6,656 | 1,350 | 8,985,600 |
| 0-47 | Henderson Inlet Area | 1,603 | | 870 | 1,890 | 200 | | 4,563 | 210.89 | 962,287 | 15,590 | 1,350 | 21,046,500 |
| 0-48 | West Budd Inlet Area | 340 | | 130 | 266 | | | 736 | 215.88 | 158,885 | 5,711 | 1,350 | 7,709,850 |
| TOTAL | DESCHUTES BASIN | 2,955 | 180 | 1,683 | 2,536 | 260 | 40 | 7,654 | Av.219.30 | 1,678,516 | 27,957 | Av.1,350 | 37,741,950 |
| 0-49 | Skookum Creek | 696 | 60 | 620 | 510 | | | 1,886 | 239.16 | 451,051 | 4,578 | 1,350 | 6,180,300 |
| 0-50 | Isabella Creek | 150 | | 200 | 108 | | | 458 | 258.97 | 118,607 | 3,062 | 1,350 | 4,133,700 |
| 0-51 | Anderson Island | 40 | 100 | | 115 | 150 | 200 | 605 | 131.72 | 79,693 | 220 | 1,350 | 297,000 |
| 0-52 | McNeil Island | | 300 | 30 | 739 | | | 1,069 | 133.55 | 142,765 | 189 | 1,350 | 255,150 |
| 0-53 | Hartstene Island | | | 30 | 394 | | | 424 | 147.33 | 62,470 | 1,617 | 1,350 | 2,182,950 |
| 0-54 | West of Shelton | 160 | | 50 | 51 | | | 261 | 234.02 | 61,080 | 2,906 | 1,350 | 3,923,100 |
| 0-55 | Northwest Shelton | 380 | | 740 | 555 | | | 1,675 | 250.14 | 418,986 | 10,338 | 1,350 | 13,956,300 |
| 0-56 | S. Fork Skokomish River | 1,451 | | 80 | | | | 1,531 | 236.87 | 362,644 | 374 | 1,350 | 504,900 |
| 0-57 | N. Fork Skokomish River | 44 | | | | | | 44 | 230.70 | 10,151 | 532 | 1,350 | 718,200 |
| 0-58 | West Hood Canal | - | - | - | - | - | - | - | - | - - | 2,470 | 1,350 | 3,334,500 |
| 0-59 | Tahuya River | 69 | | | | | | 69 | 230.70 | 15,918 | 992 | 1,350 | 1,339,200 |
| 0-60 | North Hood Canal | 192 | | 160 | 210 | | | 562 | 227.42 | 127,811 | 4,048 | 1,350 | 5,464,800 |
| 0-62 | Carr Inlet Area | 270 | 600 | 350 | 2,532 | 80 | | 3,832 | 157.60 | 603,919 | 14,549 | 1,350 | 19,641,150 |
| 0-63 | Vashon Island | 25 | | 20 | 3,746 | | | 3,791 | 133.79 | 507,215 | 3,318 | 1,350 | 4,479,300 |
| 0-66 | Hamma Hamma River | - | - | - | - | - | - | - - | - | - - | 368 | 1,350 | 496,800 |
| 0-67 | Dosewallips-Duckabush | 217 | | | | | | 217 | 230.70 | 50,062 | 1,773 | 1,350 | 2,393,550 |
| 0-68 | East Hood Canal | 178 | | | | | | 178 | 230.70 | 41,065 | 2,396 | 1,350 | 3,234,600 |
| 0-69 | West Kitsap Area | 85 | 465 | 640 | 3,420 | | | 4,610 | 162.2[illegible] | 748,107 | 18,087 | 1,350 | 24,417,450 |
| 0-70 | East Kitsap Area | 600 | 200 | 750 | 5,817 | | | 7,367 | 161.66 | 1,190,982 | 18,126 | 1,350 | 24,470,100 |
| 0-71 | Quilcene | 70 | 2 | 280 | 495 | | 80 | 927 | 199.53 | 184,965 | 1,535 | 1,350 | 2,072,250 |
| 0-72 | East Jefferson | 1,300 | | 491 | 1,703 | | 80 | 3,574 | 196.29 | 701,[illegible]32 | 12,117 | 1,350 | 16,357,950 |
| 0-73 | Chimacum | 1,300 | 42 | 478 | 2,337 | 20 | 30 | 4,207 | 186.83 | 786,013 | 862 | 1,350 | 1,163,700 |
| 0-75 | Sequim Bay Area | 80 | | 30 | 586 | 13 | | 709 | 153.52 | 108,844 | 793 | 1,350 | 1,070,550 |
| 0-76 | Johnson Creek | 100 | 1,200 | 40 | 2,468 | | | 3,808 | 131.78 | 501,815 | 1,119 | 1,350 | 1,510,650 |
| TOTAL | WEST SOUND BASINS | 7,407 | 2,969 | 4,989 | 25,786 | 263 | 390 | 41,804 | Av.174.04 | 7,275,695 | 106,369 | Av.1,350 | 143,598,150 |
| 0-77 | Dungeness River | 5,650 | 3,350 | 80 | 3,277 | | | 12,357 | 174.15 | 2,152,015 | 3,233 | 1,350 | 4,364,550 |
| 0-78 | McDonald Creek | 126 | 513 | 10 | 1,145 | | 10 | 1,804 | 135.16 | 243,826 | 177 | 1,350 | 238,950 |
| 0-79 | Siebert Creek | 2 | 912 | 40 | 1,066 | | | 2,020 | 129.10 | 260,777 | 332 | 1,350 | 448,200 |
| 0-80 | Morse Creek | 190 | 854 | 45 | 1,150 | | | 2,239 | 138.57 | 310,262 | 1,596 | 1,350 | 2,154,600 |
| 0-81 | Ennis Creek | 40 | 20 | | 79 | | | 139 | 158.08 | 21,973 | 551 | 1,350 | 743,850 |
| 0-82 | Port Angeles | 80 | 660 | 20 | 613 | | | 1,373 | 133.14 | 182,808 | 4,522 | 1,350 | 6,104,700 |
| 0-83 | Elwha River | 120 | 126 | 80 | 200 | | | 526 | 183.61 | 96,579 | 573 | 1,350 | 773,550 |
| TOTAL | ELWHA-DUNGENESS | 6,208 | 6,435 | 275 | 7,530 | | 10 | 20,458 | Av.159.75 | 3,268,240 | 10,984 | Av.1,350 | 14,828,400 |
| 0-11 | Orcas-Waldron Islands | 1,100 | 890 | 50 | 700 | 500 | | 3,240 | 174.60 | 565,712 | 3,760 | 1,350 | 5,076,000 |
| 0-12 | San Juan Island | 4,006 | 3,190 | 68 | 751 | 737 | | 8,752 | 178.53 | 1,562,518 | 4,460 | 1,350 | 6,021,000 |
| 0-13 | Lopez,Blakely,Decatur Is. | 1,918 | 2,537 | 200 | 220 | 1,323 | | 6,198 | 177.01 | 1,097,134 | 3,672 | 1,350 | 4,957,200 |
| TOTAL | SAN JUAN ISLANDS | 7,024 | 6,617 | 318 | 1,671 | 2,560 | | 18,190 | Av.177.32 | 3,225,364 | 11,892 | Av.1,350 | 16,054,200 |

1/ Any discrepancies due to rounding figures.
2/ Does not contain cost of lands expected to change from agriculture to urban use.

## TABLE 2-14. Summary of estimated drainage costs by basin and watershed (1967 price base) (Cont'd)

| Map No. | Watersheds | Cropland drainage groups: Groups 1 & 12 | Groups 2, 7, & 16 | Groups 3, 4, & 5 | Groups 6,8,9, & 11 | Groups 10 & 13 | Groups 14 & 15 | Total | Weighted cost per acre | Total cost crop-land 1/ | Urban and rural non-farm | Cost per acre | Total urban and rural non-farm 2/ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | (acres) | (acres) | (acres) | (acres) | (acres) | (acres) | (acres) | (dollars) | (dollars) | (acres) | (dollars) | (dollars) |
| 10-1 | N. Fork Nooksack River | 180 | 392 | | | | | 572 | 151.99 | 86,939 | 1,946 | 1,350 | 2,627,100 |
| 10-2 | M. Fork Nooksack River | 81 | | | | | | 81 | 230.70 | 18,687 | 260 | 1,350 | 351,000 |
| 10-3 | S. Fork Nooksack River | 2,211 | 42 | 260 | 222 | | | 2,735 | 232.15 | 634,918 | 1,406 | 1,350 | 1,898,100 |
| 10-4 | Middle Tribs. Nooksack | 3,211 | 1,654 | 391 | 1,553 | | | 6,809 | 187.07 | 1,273,744 | 1,405 | 1,350 | 1,896,750 |
| 10-5 | Anderson Creek | 380 | 350 | 45 | 1,020 | 85 | | 1,880 | 157.12 | 295,377 | 207 | 1,350 | 279,450 |
| 10-6 | Bertrand-Fishtrap Creeks | 1,646 | 439 | 3,373 | 7,020 | 1,030 | | 13,508 | 202.65 | 2,737,436 | 1,867 | 1,350 | 2,520,450 |
| 10-7 | Wiser Lake-Tenmile Area | 2,441 | 1,380 | 4,400 | 10,081 | 530 | | 18,832 | 196.11 | 3,693,056 | 1,577 | 1,350 | 2,128,950 |
| 10-8 | Lower Tribs. Nooksack | 7,317 | 480 | 578 | 3,789 | 395 | | 12,559 | 200.94 | 2,523,564 | 1,668 | 1,350 | 2,251,800 |
| 11-1 | Upper South Tribs. | | | | 79 | | | 79 | 132.00 | 10,428 | 269 | 1,350 | 363,150 |
| 11-2 | Saar Creek | 2,397 | 240 | 173 | 451 | | | 3,261 | 214.86 | 700,654 | 220 | 1,350 | 297,000 |
| 11-3 | Sumas River | 9,050 | 1,684 | 1,799 | 1,963 | 93 | 103 | 14,692 | 217.47 | 3,195,031 | 1,219 | 1,350 | 1,645,650 |
| 0-1 | Dakota Creek | 40 | | 230 | 4,936 | 1,030 | | 6,236 | 151.53 | 944,928 | 1,491 | 1,350 | 2,012,850 |
| 0-2 | Coastal Creeks | 522 | | 200 | 2,640 | 150 | | 3,512 | 161.83 | 568,351 | 3,890 | 1,350 | 5,251,500 |
| 0-3 | Terrell Creek | 40 | | 40 | 5,136 | 40 | | 5,256 | 134.90 | 709,049 | 529 | 1,350 | 714,150 |
| 0-4 | California Creek | 350 | | 580 | 5,331 | 740 | | 7,001 | 161.87 | 1,133,220 | 919 | 1,350 | 1,240,650 |
| 0-5 | Silver Creek | 805 | | 160 | 3,954 | 80 | | 4,999 | 155.89 | 779,279 | 1,264 | 1,350 | 1,706,400 |
| 0-6 | Squallcum Creek | | | 116 | 4,030 | 180 | | 4,326 | 140.56 | 608,053 | 3,842 | 1,350 | 5,186,700 |
| 0-7 | Lake Whatcom | 220 | | 170 | 176 | | | 566 | 235.46 | 133,270 | 5,303 | 1,350 | 7,159,050 |
| 0-8 | Chuckanut Mountain | 103 | | 20 | | 178 | | 301 | 219.21 | 65,981 | 3,586 | 1,350 | 4,841,100 |
| 0-9 | Lummi Island | 27 | | | 3,377 | 40 | | 3,444 | 133.54 | 459,913 | 697 | 1,350 | 940,950 |
| TOTAL NOOKSACK-SUMAS BASINS | | 31,021 | 6,661 | 12,535 | 55,758 | 4,571 | 103 | 110,649 | Av.185.92 | 20,571,878 | 33,565 | Av.1,350 | 45,312,750 |
| 9-1 | Upper Skagit River | 1,089 | 30 | | 20 | 30 | | 1,169 | 225.22 | 263,288 | 4,117 | 1,350 | 5,557,950 |
| 9-2 | Baker River | 75 | | 33 | | | | 108 | 266.76 | 28,810 | 198 | 1,350 | 267,300 |
| 9-3 | Cascade River | 78 | | | | | | 78 | 230.70 | 17,995 | 887 | 1,350 | 1,197,450 |
| 9-4 | Suiattle River | 34 | | | | | | 34 | 230.70 | 7,844 | 166 | 1,350 | 224,100 |
| 9-5 | Sauk River | 502 | | 45 | 45 | | | 592 | 232.17 | 137,444 | 3,292 | 1,350 | 4,444,200 |
| 9-6 | North Skagit Tribs. | 5,832 | 90 | 55 | 110 | 200 | 150 | 6,437 | 223.66 | 1,439,668 | 2,679 | 1,350 | 3,616,650 |
| 9-7 | South Skagit Tribs. | 1,421 | | | 20 | | 160 | 1,601 | 213.41 | 341,665 | 1,107 | 1,350 | 1,494,450 |
| 9-8 | Gages Slough | 6,962 | | 13 | 42 | 70 | | 7,087 | 230.01 | 1,630,070 | 4,841 | 1,350 | 6,535,350 |
| 9-9 | Nookachamps | 4,818 | | 384 | 769 | 650 | 19 | 6,640 | 222.43 | 1,476,963 | 2,764 | 1,350 | 3,731,400 |
| 9-10 | South Mt. Vernon | 8,130 | 634 | 50 | 1,398 | 280 | 9 | 10,501 | 210.18 | 2,207,082 | 4,231 | 1,350 | 5,711,850 |
| 0-14 | Samish River | 20,489 | 60 | 773 | 838 | 2,995 | 199 | 25,354 | 225.64 | 5,720,887 | 3,985 | 1,350 | 5,379,750 |
| 0-10 | Fidalgo Island Group | 1,660 | | 50 | 649 | 727 | | 3,086 | 204.15 | 630,012 | 6,801 | 1,350 | 9,181,350 |
| 0-15 | Skagit Flats | 26,202 | 150 | | 214 | 1,836 | | 28,402 | 227.24 | 6,453,955 | 3,828 | 1,350 | 5,167,800 |
| TOTAL SKAGIT-SAMISH BASINS | | 77,292 | 964 | 1,403 | 4,105 | 6,788 | 537 | 91,089 | Av.223.47 | 20,355,683 | 38,896 | Av.1,350 | 52,509,600 |
| 0-17 | N. Fork Stillaguamish | 3,837 | | 350 | 495 | | | 4,682 | 229.09 | 1,072,592 | 2,900 | 1,350 | 3,915,000 |
| 0-18 | S. Fork Stillaguamish | 1,300 | | 665 | 379 | | | 2,344 | 248.23 | 581,843 | 1,670 | 1,350 | 2,254,500 |
| 0-19 | Jim Creek | 455 | 50 | 40 | 125 | | | 670 | 210.76 | 141,209 | 971 | 1,350 | 1,310,850 |
| 0-20 | Pilchuck Creek | 1,157 | | 587 | 268 | | | 2,012 | 251.98 | 507,001 | 1,463 | 1,350 | 1,975,050 |
| 0-21 | Lower Stillaguamish | 9,454 | | 1,676 | 3,570 | | 307 | 15,007 | 217.11 | 3,258,239 | 4,159 | 1,350 | 5,614,650 |
| 0-22 | Churck Creek | 1,970 | | 328 | 2,126 | | | 4,424 | 192.02 | 849,494 | 1,467 | 1,350 | 1,980,450 |
| TOTAL STILLAGUAMISH BASIN | | 18,173 | 50 | 3,646 | 6,963 | | 307 | 29,139 | Av.219.99 | 6,410,378 | 12,630 | Av.1,350 | 17,050,500 |
| 0-16 | North Island | 1,620 | 1,861 | 400 | 4,667 | | 160 | 8,708 | 155.73 | 1,356,067 | 10,199 | 1,350 | 13,768,650 |
| 0-23 | Camano Island | 840 | 40 | 40 | 980 | 594 | | 2,494 | 184.18 | 459,343 | 3,862 | 1,350 | 5,213,700 |
| 0-24 | Central Island | 413 | 1,150 | 80 | 3,085 | | 617 | 5,345 | 132.24 | 706,815 | 4,332 | 1,350 | 5,848,200 |
| 0-25 | South Island | 858 | | 678 | 3,465 | | 125 | 5,126 | 175.67 | 900,510 | 5,013 | 1,350 | 6,767,550 |
| TOTAL WHIDBEY-CAMANO ISLANDS | | 3,731 | 3,051 | 1,198 | 12,197 | 594 | 902 | 21,673 | Av.157.93 | 3,422,735 | 23,406 | Av.1,350 | 31,598,100 |
| 8a | Snoqualmie River | 9,755 | 40 | 2,665 | 3,670 | | 10 | 16,140 | 227.36 | 3,669,617 | 9,374 | 1,350 | 12,654,900 |
| 8b-1 | Skykomish River | 3,911 | | 229 | 658 | | | 4,798 | 222.80 | 1,068,983 | 9,016 | 1,350 | 12,171,600 |
| 8b-2 | Sultan River | 249 | | 94 | 20 | | | 363 | 255.83 | 92,865 | 417 | 1,350 | 562,950 |
| 8b-4 | Woods Creek | 1,058 | 315 | 380 | 1,391 | | | 3,144 | 189.79 | 596,703 | 1,590 | 1,350 | 2,146,500 |
| 8-1 | Pilchuck River | 2,448 | 135 | 1,870 | 1,632 | | | 6,085 | 237.95 | 1,447,943 | 7,282 | 1,350 | 9,830,700 |
| 8-2 | French Creek | 2,841 | 30 | 3,010 | 1,189 | | | 7,070 | 263.86 | 1,86[illegible],520 | 2,060 | 1,350 | 2,781,000 |
| 8-3 | Cathcart Area | 1,040 | | 112 | 478 | | | 1,630 | 209.87 | 342,082 | 567 | 1,350 | 765,450 |
| 8-4 | Snohomish Estuary | 3,713 | | 2,701 | 11,324 | | 40 | 17,778 | 185.40 | 3,296,077 | 15,270 | 1,350 | 20,614,500 |
| 8-5 | Marshland Area | 2,708 | | 2,883 | 40 | | | 5,631 | 290.43 | 1,635,405 | 2,312 | 1,350 | 3,121,200 |
| 0-26 | Edmonds-Mukilteo | - | - | - | -- | - | - | - | -- | - - | 14,873 | 1,350 | 20,078,550 |
| 0-33 | Tulalip-Warm Beach | 404 | | 100 | 164 | | | 668 | 224.14 | 149,724 | 2,954 | 1,350 | 3,987,900 |
| TOTAL SNOHOMISH BASIN | | 28,127 | 520 | 14,044 | 20,566 | | 50 | 63,307 | Av.223.75 | 14,164,919 | 65,715 | Av.1,350 | 88,715,250 |
| 0-27 | Swamp,Bear,North Creeks | 928 | | 1,581 | 1,317 | | | 3,826 | 245.50 | 939,276 | 21,008 | 1,350 | 28,360,800 |
| 0-28 | Lake Washington | 435 | | 533 | 507 | | | 1,475 | 239.42 | 353,151 | 64,797 | 1,350 | 87,475,950 |
| 0-29 | Upper West Slope Seattle | - | - | -- | - | - | -- | - | - | - - | 20,392 | 1,350 | 27,529,200 |
| 0-30 | Sammamish River | 2,307 | | 2,154 | 6,010 | | 169 | 10,640 | 196.29 | 2,088,539 | 18,517 | 1,350 | 24,997,950 |
| 0-31 | Cedar River | 650 | 370 | 362 | 235 | | 20 | 1,637 | 214.71 | 351,479 | 7,181 | 1,350 | 9,694,350 |
| TOTAL CEDAR BASIN | | 4,320 | 370 | 4,630 | 8,069 | | 189 | 17,578 | Av.212.34 | 3,732,445 | 131,895 | Av.1,350 | 178,058,250 |

In arriving at these costs, the 1967 average installation costs in the Puget Sound Area were evaluated. Unit costs were taken as $.75 per foot for six-inch lines; $1 per foot in soils where trenching is more difficult; and $1.15 per foot for eight-inch outlet lines. These costs are approximately doubled where graded filter needs to be placed around the tile.

Drainage benefits have been developed more fully in Appendix V, Chapter 2, Agriculture, by comparing farm budgets before and after drainage. These net benefits have been found to equal $16.10 an acre[1] on the average. While costs vary somewhat with location, land condition, and farm operation, they illustrate that benefits from drainage, provided drainage outlets are available, and provided certain tax relief, credit assistance, marketing, and other minimum conditions related to the economic stability of the farm unit are maintained. These benefits are sufficient to conclude that the drainage described will be installed by private enterprise during the years indicated. The net benefit shown above represents an average value. Obviously this value should not be used for a specific site without further consideration. Assistance on site determination or outlets may be obtained by land managers from the local soil and water conservation districts.

### Urban Drainage

Areas under urban development have a high proportion of the area under roofs and paving which causes excess water to flow onto exposed land areas within the development. Even well-drained soils require drainage facilities to dispose of excess water during infrequent storms. Permanent drainage installations are considered necessary on all lands in urban developments in the Puget Sound Area. The proposal in this Appendix provides that all land devoted to urban development will have adequate drainage installed by the year 2020.

Based on the development density of approximately three houses per acre, the average development cost is estimated at about $1,350 per acre. This is for developments located on moderately good sites. No estimate is made for developments on essentially unstable soil sites. Each site developed should be examined for specific needs.

Benefits are considered to be far in excess of the computed average annual cost of $33, approximately, per house. Additional benefits to be realized from drainage occur in the form of reduced shrink-swell of the soil which results in stable floors and foundations; reduction of dry rot in sills and floor joists; and reduction of water seeps into basements. This drainage cost does not provide outlets for storm surface waters, and the Drainage and Land Stabilization Committee has found no method of calculating expected costs for urban surface water removal.

## IRRIGATION

Irrigation of cropland has historically been by individual initiative, largely using portable sprinkler distribution of water supplied by private pumping from ground water supplies or diversion from streams or farm ponds. Community irrigation districts or companies operate in the Dungeness Basin where natural rainfall is lower than for the greater part of the Area. There are at least two potential project-type developments for irrigation reported in Appendix VII, Irrigation.

Irrigation will continue to be largely by individual choice through 1980 and will be based to a large extent on profit incentive, depending on future market conditions in the Area. Irrigated cropland needed in 2020, projected on the basis of full development of land used for crops, is 396,000 acres.[2] The Irrigation Committee estimates the amount irrigated in 2020 will be 223,000 acres (Appendix VII, Irrigation, Table 2-12). The difference of 173,000 acres of irrigated land, if borne out by future events, will represent a production deficiency and will add to the relative future imports required for the Area.

Potentials exist for the use of cooling water derived from thermal power generation and other sources for irrigation in lieu of cooling operations. A potential for irrigation of forest land also exists.[3]

[1] See Appendix V, Water-Related Land Resources, Chapter 2, Agriculture, Exhibit 6.

[2] Appendix V, Water-Related Land Resources, Chapter 2, Agriculture.

[3] Appendix V, Water-Related Land Resources, Chapter 3, Forests.

# IMPLEMENTATION OF PLAN

## COMPREHENSIVE PROGRAM FOR WATERSHED MANAGEMENT

The results of the coordinated studies undertaken in the Puget Sound Area indicate a need for establishing, by time periods, those land treatment and management measures and practices that will enhance the conservation and development of water and related land resources. The application of watershed protection and improvement practices on all land according to its use and capability will reduce erosion and the resultant sediment pollution of rivers, streams, and reservoirs; result in improved hydrologic conditions; and contribute to sustained productivity of forest lands, croplands, and range lands. The recreation and wildlife practices will increase the private sector's participation in this field of conservation effort. The application of projects and conservation measures will contribute to environmental qualities, natural beauty, and other elements essential to wholesome living.

The coordinated study reveals a need for structural works of improvement for flood prevention and flood control, and a need for drainage of lands to permit more intensive use. Irrigation will be required to achieve production levels expected from some croplands.

The study indicates a need for practices related to specific use and multiple use of lands to achieve their potential for fish and wildlife habitat, recreation, municipal and industrial water, high or sustained water quality, and related desirable environmental qualities.

The program of watershed management is planned to bring about improvements in the use and management of the land and water to meet increasing needs of the population in the time periods covered by this study. The program provides for shifts in land use as needs of the population increase, and provides for development of urban and rural lands in a balance planned to conserve and develop environmental qualities of the Area while permitting continued economic development. There are adequate land and water resources to permit this program to be effective, provided the use of resources is planned to achieve an average population density of six or more persons per acre in areas to be developed for urban use; and providing the present adverse trends in expansion of unplanned urban growth into the best agricultural lands are reversed. These lands are located mainly in the alluvial flood plains of the rivers and tributary streams of the Area. Certain policy clarification and legislative improvement, together with other incentives, funding, and supervision, are required to achieve better long-range utilization and management.

## ROLE OF COOPERATING AGENCIES AND INDIVIDUALS

### Private Sector

Much watershed land is managed by private enterprise, and there is great diversity of scope and purpose in management. Activities affecting the land surface affect the land-water relationship, and these activities vary within the entire range of human enterprise. Most private enterprise activities depend on a profit motive. Some of these activities are regulated in the public interest; others frequently are assisted by government at all levels through contributions of technical assistance or other services, and by financial or credit assistance, lower taxes, or other incentives.

### State of Washington

The State manages large areas of land under its administration and assists in financing flood control, water supply, drainage, and conservation planning. The State has the responsibility of reviewing structures erected in flood plains, and exercises broad powers in pollution prevention. Much State activity is directed into cooperative relations with the Federal Government and the private sector. Subdivisions of the State (counties, cities, and functional districts) have broad powers to undertake or sponsor improvement projects for watershed management purposes. The State has an important role in coordinating significant portions of Federal programs affecting non-Federal lands.

### Federal Government

Many agencies of the Federal Government cooperate directly with the private sector, the State, and other Federal agencies, whose roles are outlined here. A few of the agencies most directly involved are listed individually.

The United States Army Corps of Engineers, through its civil works program, provides investiga-

tion and construction of works of improvement for navigation, flood control, and other functions, as authorized by Congress. In addition, in emergencies the Corps engages in repair of flood control facilities, and, when called upon, in flood fighting and rescue work. Major flood control projects of the Corps are described in Appendix XII, Flood Control, and are not repeated here. Adequate protection from flood damage is a prerequisite for many subsequent investments in development of land and management of water.

The United States Department of Agriculture, through its various agencies, provides technical and financial assistance to local organizations, including the State and its subdivisions, in flood prevention, water management, some aspects of pollution prevention, and related conservation activities. The program and projects of the Department of Agriculture are given later in this Appendix, as this information is not presented elsewhere.

Early action projects presented in the Department of Agriculture's program have been coordinated with Corps of Engineers' projects for early action, listed in Appendix XII. Final coordination with Corps of Engineers' projects and with projects of the State of Washington at the project level will depend on timely authorization procedures for full benefits. Similar coordination with Department of the Interior activities will be handled at the project level with the assistance of the State.

The Bureau of Reclamation, United States Department of the Interior, has authority to construct irrigation facilities; to assist in replacing or repairing irrigation and related facilities damaged by flood or similar disaster; and to construct water storage facilities for multiple purposes, including development, protection, conservation, and preservation. The program of the Bureau of Reclamation is given in Appendix XII, Irrigation.

Department of the Interior programs cover a broad area of conservation and preservation objectives, including the management of substantial areas of land in national wildlife refuges and national parks in the Puget Sound Area.

Other cooperating agencies include the Weather Bureau, of the United States Department of Commerce, the United States Department of Housing and Urban Development, and the Office of Emergency Planning.

## MEASURES FOR REHABILITATION AND PROTECTION OF WATERSHED LANDS

Measures for the rehabilitation and protection of watershed lands consist of: (a) treatment to restore damaged land as nearly as practical to its former state of reserve productivity; (b) use of the land within its capabilities; and (c) treatment within practical limits, according to its chosen use to prevent further deterioration of soil and water resources. Other measures are planned to reduce damages from floodwater and sediment, assist in stabilization of critical areas, or to achieve management benefits stemming from improved conservation management of land and water resources. Measures are usually applied in groups for effectiveness; thus, a given acre may have one or more measures selected in kind and intensity of application and applied in combinations planned to achieve protection under practical conditions of use or development. Functions benefiting generally or specifically from installation of planned measures cover a wide spectrum but usually include farming, forestry, recreation, fish and wildlife habitat, water quality, water supply, urban uses, and general hydrologic condition.

The responsibility for installing these measures generally will fall on the owner of the land. In the case of public lands, this responsibility belongs to the administrative agency.

## ESTIMATED COSTS

Programs for development and management of resources to satisfy the needs of a population of 6.8 million expected by 2020 will require the expenditure of considerable sums of money, both public and private. Continuing and accelerating the current programs will be required, plus construction of projects.

Summaries of estimated program costs, by time periods, are given in Tables 2-15, 2-16, and 2-17. These costs do not include flood control or other costs reported in separate appendices.

The unit costs used in estimating figures under "Federal" are those associated with United States Department of Agriculture programs or their equivalent. Examples of such programs are those administered by the Forest Service, the Soil Conservation Service, the Agricultural Stabilization and Conserva-

tion Service and the Cooperative Extension Service. Management costs estimated for Federal lands are listed under "Federal." The Federal costs are based on 1967 prices and where these costs are amortized to compute benefit-cost comparisons, an interest rate of 4-5/8 percent for a 100-year term has been used.

Technical assistance and management costs on lands administered by the Washington State Department of Natural Resources are based on 1964 prices.

"Other" or private costs are considered to be met by funds derived from the private sector in conformity with existing administrative policy to meet the non-Federal share of installation, operation, and maintenance of project works of improvement, as well as funds required for other management. These costs are based on 1967 dollars and where amortized, a 6 percent rate for a 30-year period is used.

It sould be noted that private costs shown in the tables are cumulative by time periods and include costs borne by local improvement districts as well as private individuals. A large share of these costs are ongoing management costs incurred whether or not this proposed plan is implemented. In this category are developmental and maintenance costs expected to be incurred to achieve known potentials. The early action projects will provide incentives and opportunities for feasible optional investment and redirected management to develop the Area in line with the prudent economic opportunity of future years. Logically, the true cost of the plan would be the net difference between costs currently incurred and costs with the plan, but because of the redirected management and other variables implied, this net difference in cost has not been computed. The total expected cost is therefore used to compute benefit and cost comparisons.

## DEPARTMENT OF AGRICULTURE EARLY ACTION AND OTHER PROGRAMS

The programs of the United States Department of Agriculture include a large part of the technical and financial assistance furnished for installing watershed rehabilitation and protection measures on private lands, as well as for the installation of similar measures on national forest lands. This work includes extensive cooperation with various State and Federal agencies in areas of mutual responsibility. On-going programs of the Department are expected to continue, with redirection as necessary to best meet the needs of the times.

**TABLE 2-15. Summary of program costs first 15 years, Puget Sound Area[1] (in thousands of dollars)**

| | Federal Costs (USDA) | | | State and Other Costs Including Private Investment | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Basin | Technical Assist. &[2] Manage.[3] | Structural Measures Installation[3] | Accelerated Technical Assistance | Technical Assist. & Manage. | Structural Measures | Rights-of-Way | Operation Maint. & Replace. Structural Measures[4] | Water Manage. | Urban Drainage | Land Treatment | Total |
| Nooksack-Sumas | 10,594 | 7,738 | 501 | 8,456 | 1,357 | 1,879 | 2,469 | 14,616 | 15,404 | 10,961 | 73,974 |
| Skagit-Samish | 31,750 | 7,225 | 245 | 9,585 | 1,287 | 2,125 | 2,393 | 14,063 | 22,795 | 9,118 | 100,586 |
| Stillaguamish | 7,377 | 1,149 | 58 | 5,325 | 235 | 261 | 370 | 4,814 | 7,595 | 3,524 | 30,708 |
| Whidbey-Camano | 1,117 | 0 | 0 | 1,124 | 0 | 0 | 0 | 1,523 | 10,533 | 1,969 | 16,266 |
| Snohomish | 19,823 | 1,881 | 641 | 14,428 | 324 | 298 | 563 | 7,994 | 58,522 | 7,096 | 111,570 |
| Cedar | 4,446 | 1,529 | 1,329 | 3,763 | 80 | 571 | 491 | 930 | 139,316 | 1,352 | 153,807 |
| Green | 7,020 | 0 | 0 | 3,079 | 0 | 0 | 0 | 2,159 | 59,754 | 2,806 | 74,818 |
| Puyallup | 10,094 | 3,025 | 445 | 7,897 | 469 | 1,478 | 1,119 | 2,790 | 110,701 | 3,745 | 141,763 |
| Nisqually | 4,537 | 0 | 0 | 7,961 | 0 | 0 | 0 | 689 | 5,374 | 3,184 | 21,745 |
| Deschutes | 1,317 | 0 | 0 | 3,096 | 0 | 0 | 0 | 441 | 12,539 | 1,572 | 18,965 |
| West Sound | 19,764 | 736 | 206 | 19,718 | 27 | 316 | 243 | 3,743 | 47,866 | 6,108 | 98,726 |
| Elwha-Dungeness | 7,037 | 0 | 0 | 2,205 | 0 | 0 | 0 | 1,761 | 4,942 | 1,907 | 17,852 |
| San Juan | 2,134 | 0 | 0 | 990 | 0 | 0 | 0 | 1,828 | 5,361 | 1,594 | 11,897 |
| Total | 127,010 | 23,077 | 3,424 | 87,627 | 3,984 | 6,928 | 7,648 | 57,361 | 500,692 | 54,936[5] | 872,677 |

[1] Base: 1967 prices.

[2] Does not include technical assistance and management costs for urban drainage.

[3] Does not include costs of flood control. (See Appendix XII, Flood Control).

[4] Base: 1967 adjusted normalized prices.

[5] The sum of $500,000 should be added for a detailed study of beach erosion problems and remedies under leadership of the Department of the Army. In addition, $2,250,000 should be added for cooperative monitoring of sediment and $3,000,000 for cooperative soil surveys under leadership of the USDA.

**TABLE 2-16. Summary of program costs, 1980-2000, Puget Sound Area[1] (in thousands of dollars)**

| | Federal Costs (USDA) | | | State and Other Costs Including Private Investment | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Basin | Technical Assist. &[2,3] Manage.* | Structural Measures Installation[3] | Accelerated Technical Assistance* | Technical Assist. & Manage.* | Operation Maint. & Replace. Structural Measures | Water Manage. | Urban Drainage | Land Treatment | Total |
| Nooksack-Sumas | 11,863 | 5,950 | 501 | 11,276 | 1,785 | 17,864 | 14,271 | 14,614 | 78,124 |
| Skagit-Samish | 42,147 | 1,850 | 245 | 12,779 | 555 | 17,606 | 14,292 | 12,157 | 101,631 |
| Stillaguamish | 9,776 | 5,620 | 115 | 7,100 | 1,686 | 2,925 | 5,225 | 4,339 | 36,786 |
| Whidbey-Camano | 1,553 | 3,245 | 71 | 1,498 | 973 | 2,566 | 10,099 | 2,625 | 22,630 |
| Snohomish | 41,209 | 12,240 | 1,496 | 19,238 | 3,672 | 5,036 | 58,522 | 8,726 | 150,139 |
| Cedar | 7,667 | 3,810 | 1,329 | 5,018 | 1,143 | 660 | 135,219 | 1,432 | 156,278 |
| Green | 12,239 | 1,700 | 443 | 4,106 | 510 | 1,413 | 57,996 | 2,779 | 81,186 |
| Puyallup | 19,171 | 4,167 | 593 | 10,529 | 600 | 2,759 | 56,114 | 4,957 | 98,890 |
| Nisqually | 8,406 | 2,930 | 458 | 10,615 | 879 | 579 | 10,437 | 4,245 | 38,549 |
| Deschutes | 2,118 | 1,410 | 344 | 4,128 | 423 | 354 | 24,351 | 2,096 | 35,224 |
| West Sound | 33,142 | 8,055 | 1,637 | 26,291 | 2,417 | 2,388 | 50,100 | 8,144 | 132,174 |
| Elwha-Dungeness | 11,487 | 2,962 | 232 | 2,940 | 889 | 1,227 | 4,801 | 2,542 | 27,080 |
| San Juan | 2,871 | 2,736 | 135 | 1,321 | 821 | 2,436 | 5,100 | 2,126 | 17,546 |
| Total | 203,649 | 56,675 | 7,599 | 116,839 | 16,353 | 57,813 | 446,527 | 70,782[4] | 976,237 |

[1] Base: 1967 adjusted normalized prices, except items asterisked.

[2] Does not include technical assistance and management costs for urban drainage.

[3] Does not include costs of flood control. (See Appendix XII, Flood Control).

[4] The sum of $100 million should be added for beach stabilization under leadership of the Department of the Army; and $150,000 annually for cooperative sediment monitoring under leadership of the USDA.

Some of the principal legislative authorities for programs of the Department of Agriculture related to watershed management activities are listed here. Many of these Acts have been modified by amendments and further information is given in Appendix II, Political and Legislative Environment, or may be obtained from Departmental sources.

- Soil Conservation Service Act (PL 46, 1935)
- Omnibus Flood Control Act (PL 738, 1936)
- Flood Control Act (PL 534, 1944)
- Watershed Protection and Flood Prevention Act (PL 566, 1954)
- Plains Conservation Act (PL 1021, 1956)
- Resource Conservation and Development Act (PL 87-703, 1962)
- Agricultural Conservation and Domestic Allotment Act (PL 74, Stat. 163)
- Agricultural Stabilization Act (PL 88-26, Stat. 44, and others)
- Cooperative Agriculture and Forest Research Act (PL 84-352, 69 Stat. 671)
- Cooperative Extension Act (PL 83-83, 1914)
- Farmers Cooperative Service Act (PL 44, Stat. 802, 1926)
- Consolidated Farmers Home Administration Act (1961)
- Forest Service Cooperative State and Private Programs Act (PL 43-653, 1924)
- Forest Products Act (PL 70-466, 1928)
- Agricultural Stabilization Act (PL 81-439, 1949, and others)
- Rural Electrification Act (74-605, 1936)

Federally appropriated funds are managed to maintain watershed rehabilitation and protection measures on lands administered by the Department. Similarly, appropriated funds enable the Department to participate in cooperative programs with other Federal agencies and with the State of Washington in planning and installing such measures on other lands. In this way, technical and financial assistance is extended to governmental subdivisions of the State, to informal management organizations, and to

TABLE 2-17. Summary of program costs, 2000-2020, Puget Sound Area[1] (in thousands of dollars)

| | Federal Costs (USDA) | | | State and Other Costs Including Private Investment | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Basin | Technical Assist. &[2,3] Manage.* | Structural Measures Installation[3] | Accelerated Technical Assistance* | Technical Assist. & Manage.* | Operation Maint. & Replace. Structural Measures | Water Manage. | Urban Drainage | Land Treatment | Total |
| Nooksack-Sumas | 10,708 | 936 | 418 | 11,275 | 281 | 12,720 | 15,638 | 14,614 | 66,590 |
| Skagit-Samish | 36,596 | 1,460 | 409 | 12,779 | 438 | 31,955 | 15,422 | 12,157 | 111,216 |
| Stillaguamish | 7,993 | 1,310 | 115 | 7,100 | 393 | 4,315 | 4,686 | 4,338 | 30,250 |
| Whidbey-Camano | 1,553 | 0 | 0 | 1,498 | 0 | 3,000 | 10,966 | 2,625 | 19,642 |
| Snohomish | 42,628 | 100 | 214 | 19,238 | 30 | 6,797 | 58,522 | 8,141 | 135,670 |
| Cedar | 7,661 | 100 | 443 | 5,018 | 30 | 1,671 | 135,219 | 900 | 151,042 |
| Green | 12,235 | 100 | 443 | 4,106 | 30 | 2,244 | 57,996 | 2,108 | 79,262 |
| Puyallup | 19,564 | 0 | 0 | 10,529 | 0 | 3,000 | 101,137 | 4,034 | 138,264 |
| Nisqually | 8,652 | 100 | 115 | 10,615 | 30 | 959 | 320 | 4,245 | 25,036 |
| Deschutes | 2,155 | 0 | 0 | 4,128 | 0 | 369 | 852 | 2,096 | 9,600 |
| West Sound | 36,336 | 970 | 955 | 26,291 | 291 | 3,257 | 45,633 | 8,144 | 121,877 |
| Elwha-Dungeness | 12,121 | 300 | 93 | 2,940 | 90 | 1,656 | 5,085 | 2,542 | 24,827 |
| San Juan | 2,871 | 0 | 0 | 1,321 | 0 | 1,800 | 5,602 | 2,126 | 13,720 |
| Total | 201,073 | 5,376 | 3,205 | 116,838 | 1,613 | 73,743 | 457,078 | 68,070[4] | 926,996 |

[1] Base: 1967 adjusted normalized prices, except items asterisked.

[2] Does not include technical assistance and management costs for urban drainage.

[3] *Does not include costs of flood control. (See Appendix XII, Flood Control).*

[4] The sum of $100 million should be added for beach stabilization under leadership of the Department of the Army; and $150,000 annually for cooperative sediment monitoring under leadership of the USDA.

individual owners and operators in this work.

Costs of measures applied to federally administered lands are from funds of the administering agency. Measures applied to units of privately-owned lands are primarily at the expense of the private sector with technical assistance through agencies of the United States Department of Agriculture.

On behalf of the Department of Agriculture, the Soil Conservation Service provides under Public Law 566 and other authorities coordinated assistance to local groups for flood prevention, land treatment, and the conservation, development, utilization, and disposal of water in watershed areas and in developing potentials for related purposes. The Forest Service administers large areas of federally-owned land in national forests, and cooperates with the State and private sector in cooperative management programs, including protection, research, and development. Some of the major accomplishments of present programs of these agencies, and programs proposed for future time frames, are given in Tables 2-18 and 2-19.

The present level of agricultural development in much of the Area is limited by lack of effective community-type structural measures for flood prevention and agricultural water management. Reduction of damages from floodwater and sediment is generally the first increment of development for croplands and other lands having a flood hazard, followed by community facilities for agricultural water management for improvement of production efficiency. Measures of a community nature or having widespread benefits may qualify as local projects that can be constructed with technical assistance and

TABLE 2-18. **Partial listing of measures for watershed protection and management on cropland (programs of Soil Conservation Service, USDA)**

| Treatment Measures | Unit | Early Action Program: Appl. Cum. Through 1966[2] | Early Action Program: 1980 | Proposed for Installation: 2000 | Proposed for Installation: 2020 | Total |
|---|---|---|---|---|---|---|
| **Erosion Control Measures** | | | | | | |
| Conservation cropping system | acre | 210,600 | 58,000 | 115,700 | 115,700 | 500,000 |
| Pasture and hayland planting[1] | acre | 10,000 | 5,000 | 10,000 | 10,000 | 35,000 |
| Cover crop[1] | acre | 24,000 | 28,800 | 57,500 | 57,500 | 167,800 |
| **Flood Prevention Measures** | | | | | | |
| Dike and levee | feet | 1,443,790 | 154,810 | 309,500 | 309,500 | 2,217,600 |
| Clearing and snagging | feet | 211,500 | 380,460 | 760,020 | 760,020 | 2,112,000 |
| Streambank protection | feet | 892,500 | 143,580 | 287,160 | 287,160 | 1,610,400 |
| Stream channel improvement | feet | 459,580 | 76,960 | 153,930 | 153,930 | 844,400 |
| Stream channel stabilization | feet | 25,350 | 17,110 | 34,210 | 34,210 | 110,880 |
| **Drainage Measures** | | | | | | |
| Drainage main or lateral | feet | 7,042,420 | 1,391,520 | 2,783,030 | 2,783,030 | 14,000,000 |
| Drainage field ditch | feet | 81,470 | 2,152,710 | 4,305,410 | 4,305,410 | 10,845,000 |
| Tile drain | feet | 5,790,860 | 11,133,240 | 22,266,450 | 22,266,450 | 61,457,000 |
| **Irrigation Measures** | | | | | | |
| Irrigation system, sprinkler | number | 2,210 | 870 | 1,760 | 1,760 | 6,600 |
| Pipeline | feet | 288,500 | 191,780 | 383,560 | 383,560 | 1,247,400 |
| Irrigation water management | acre | 91,700 | 46,300 | 42,500 | 42,500 | 223,000 |
| Irrigation pit or regulating reservoir | number | 320 | 210 | 420 | 420 | 1,370 |
| **Recreation Measures** | | | | | | |
| Recreation access road | feet | 1,105,350 | 444,210 | 888,420 | 888,420 | 3,326,400 |
| Wildlife habitat management | acre | 107,180 | 192,940 | 385,850 | 385,850 | 1,071,820 |
| Farm pond | number | 1,010 | 390 | 800 | 800 | 3,000 |

[1] Conservation measures applied annually.

[2] This includes accomplishments that are part of SCS Records System.

grants-in-aid from the Department of Agriculture in amounts depending on the nature and distribution of benefits. Loans are also available for the local share of such projects from Departmental funds when required.

The early action program contains projects for installation before 1980 in recognition of a rapidly increasing population creating needs in the Area approaching an emergency situation. Planning at the project level involves concerned agencies of the Federal Government and the State of Washington.

Appendix XII, Flood Control, recommends 28 projects requiring early action to reduce damages from stream overflow on the main stems of rivers in the Puget Sound Area. Appendix XIV recommends 25 projects in an early action program, primarily for flood prevention and drainage, to be coordinated with flood control works to achieve the full benefits made possible by works of improvement.

The early action programs recommended for installation within the next 10 to 15 years include projects for construction of structural measures and plans for installing land treatment measures in areas of immediate need.

TABLE 2-19. Partial listing of measures for watershed protection and management on national forests (programs of Forest Service, USDA)

| Treatment Measures | Unit | Early Action Program 1965-1980 | Early Action Program Percent[1] | Proposed for Installation 1980-2000 | Proposed for Installation 2000-2020 |
|---|---|---|---|---|---|
| **Managerial** | | | | | |
| Surveys | acre | 8,875,970 | 95 | 5,048,170 | 0 |
| Plans for watersheds | number | 87 | 100 | 41 | 0 |
| Research, studies[2] | dollar | 461,600 | 30 | 559,400 | 559,400 |
| State and private programs[2] | dollar | 2,317,700 | 95 | 3,090,200 | 3,090,200 |
| **Protection** | | | | | |
| Fire control | acre | 3,095,080 | 50 | 3,095,080 | 3,095,080 |
| Insect and disease control[2,3] | dollar | 32,500 | 95 | 43,500 | 43,500 |
| Road development | | | | | |
| Permanent | mile | 2,429 | 75 | 3,770 | 2,460 |
| Temporary | mile | 9,432 | 60 | 16,810 | 20,705 |
| Land use development | | | | | |
| Logging[5] | acre | 402,280 | 95 | 717,300 | 883,080 |
| Grazing | acre | 11,720 | 75 | 32,020 | 64,600 |
| Recreation[2] | dollar | 4,885,000 | 30 | 6,513,500 | 6,513,500 |
| **Restoration** | | | | | |
| Reforestation | acre | 199,530 | 95 | 272,300 | 272,300 |
| Gully stabilization | mile | 17.5 | 5 | 25 | 25 |
| Erosion control | acre | 5,310 | 5 | 5,910 | 5,910 |
| Channel clearance | mile | 83.7 | 10 | 150.3 | 150.3 |
| Bank stabilization | mile | 143.4 | 5 | 156.5 | 156.5 |
| Road and trail rehabilitation | acre | 150.2 | 5 | 206 | 206 |
| Roadside stabilization | acre | 756 | 5 | 955 | 955 |
| **Water Yield Improvement**[4] | | | | | |
| Cover-type conversion | acre | 0 | 0 | 40,750 | 40,450 |
| Snowpack management facilities | mile | 0 | 0 | 810 | 798 |
| Sediment basin construction | acre | 420 | 0 | 1,975 | 1,885 |
| Flow regulation structures | each | 40 | 0 | 45 | 43 |
| Water storage structures | each | 63 | 0 | 276 | 278 |
| Wetland drainage structures | each | 2 | 0 | 8 | 0 |

[1] Approximate percentage of needs met by current funding levels.

[2] Based on allocation of total Regional program.

[3] Costs include detection only.

[4] Measures based on local determination of future offsite needs for water. These should be viewed as potential developments rather than specifically planned projects.

[5] Area includes thinnings and release cuttings as well as harvest cuts.

These early action projects are summarized for the Area in Table 2-20 and are described in additional detail under appropriate basin headings.

Project installation costs are estimated primarily on the basis of proposed structural measures for floodwater damage prevention and drainage believed needed to permit full cropland development and other development under optimum watershed management. Potential exists for including other purposes in such projects.

The minimum level of protection against flood damage considered necessary for agricultural and other open use lands in the Puget Sound Area was taken, in formulating these projects, as the 10-year recurrence frequency flood event. Protection at this level implies the need to regulate the use of hazardous

## TABLE 2-20. Early action projects of USDA recommended for installation by 1980

| Map No. | Basin & Watershed | Project Area | Channel Improvement | Modification of Existing Protective Works | Outlet & Water Control Structures | Water Storage Facilities & Debris Basins | Floodwater Protection | Average Annual Flood Damage[1] | Drainage Improvement | Total Annual Flood Protection & Drainage Benefits | Average Annual Floodwater & Drainage Cost[2] | Project Structural Measures Cost[3] | Benefit Cost Ratio |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | (acres) | (mi.) | (mi.) | (no.) | (ac. ft.) | (acres) | (dollars) | (acres) | (dollars) | (dollars) | (dollars) | |
| | NOOKSACK-SUMAS BASINS | | | | | | | | | | | | |
| 10-4 | Middle Tribs. Nooksack[4] | 6,750 | 6.7 | 5.0 | 1 | | 3,199 | 67,590 | 4,582 | 131,230 | 55,048 | 986,000 | 2.4:1 |
| 10-6 | *Fishtrap-Bertrand Creek* | 23,914 | 37.0 | 6.0 | 2 | | 13,159 | 276,320 | 13,508 | 435,615 | 103,654 | 1,854,000 | 4.2:1 |
| 10-7 | Wiser Lake Area | 38,305 | 29.0 | 10.1 | 4 | | 14,791 | 314,540 | 18,832 | 566,189 | 137,399 | 2,448,000 | 4.1:1 |
| 10-8 | Lower Nooksack Tribs. | 19,835 | 18.9 | 9.3 | 5 | | 10,499 | 221,830 | 12,559 | 377,821 | 134,776 | 2,370,000 | 2.8:1 |
| 11-3 | Sumas River | 33,079 | 22.0 | | | 10[5] | 14,509 | 304,800 | 14,692 | 461,576 | 68,137 | 1,241,000 | 6.8:1 |
| 0-1 | Dakota Creek | 20,314 | 18.0 | | | | 593 | 11,700 | 3,118 | 67,992 | 23,281 | 430,000 | 2.9:1 |
| 0-4 | *California Creek* | 14,192 | 13.8 | | | 1,500 | 1,397 | 29,340 | 3,500 | 87,761 | 25,603 | 471,000 | 3.4:1 |
| 0-5 | Silver Creek | 10,866 | 16.0 | 5.0 | 1 | | 2,736 | 57,820 | 4,999 | 141,066 | 66,302 | 1,173,000 | 2.1:1 |
| | Total | 167,255 | 161.4 | 35.4 | 13 | 1,510 | 60,883 | 1,283,940 | 75,790 | 2,269,250 | 614,200 | 10,973,000 | 3.7:1 |
| | SKAGIT-SAMISH BASINS | | | | | | | | | | | | |
| 9-8 | Gages Slough | 14,419 | 17.0 | | 1 | | 9,520 | 187,630 | 7,087 | 243,519 | 60,919 | 1,107,000 | 4.0:1 |
| 9-10 | South Mt. Vernon | 32,132 | 21.5 | | 4 | | 9,619 | 202,200 | 10,501 | 322,408 | 80,630 | 1,434,000 | 4.0:1 |
| 0-14 | Samish River[4] | 63,716 | 65.0 | | 5 | | 23,859 | 509,640 | 24,028 | 754,678 | 271,712 | 4,862,000 | 2.8:1 |
| 0-15 | Skagit Flats | 41,148 | 43.0 | 5.0 | 5 | | 31,788 | 655,630 | 28,402 | 921,228 | 180,290 | 3,234,000 | 5.1:1 |
| | Total | 151,415 | 146.5 | 5.0 | 15 | | 74,786 | 1,555,100 | 70,018 | 2,241,833 | 593,551 | 10,637,000 | 3.8:1 |
| | STILLAGUAMISH BASIN | | | | | | | | | | | | |
| 0-21 | Lower Stillaguamish[4] | 8,522 | 17.0 | 1.0 | 3 | | 5,547 | 114,970 | 5,422 | 171,737 | 54,272 | 980,000 | 3.2:1 |
| 0-22 | Church Creek | 8,060 | 8.4 | 1.0 | 3 | | 2,732 | 55,810 | 4,424 | 116,112 | 37,325 | 665,000 | 3.1:1 |
| | Total | 16,582 | 25.4 | 2.0 | 6 | | 8,279 | 170,780 | 9,846 | 287,849 | 91,597 | 1,645,000 | 3.1:1 |
| | SNOHOMISH BASIN | | | | | | | | | | | | |
| 8a-1 | Patterson Creek[4] | 12,451 | 8.0 | | | | 667 | 14,310 | 1,426 | 32,978 | 21,282 | 392,000 | 1.5:1 |
| 8-4 | Snohomish Estuary[4] | 25,759 | 15.0 | 11.0 | 3 | | 12,321 | 244,100 | 10,222 | 363,787 | 120,753 | 2,111,000 | 3.0:1 |
| | Total | 38,210 | 23.0 | 11.0 | 3 | | 12,988 | 258,410 | 11,648 | 396,765 | 142,035 | 2,503,000 | 2.8:1 |
| | CEDAR BASIN | | | | | | | | | | | | |
| 0-27 | Swamp, Bear, North Crs. | 44,795 | 24.0 | | 2 | | 5,963 | 113,520 | 3,826 | 134,634 | 63,501 | 1,165,000 | 2.1:1 |
| 0-30 | Evans Creek[4] | 28,800 | 16.0 | | 2 | | 3,348 | 64,510 | 3,620 | 107,229 | 55,399 | 1,015,000 | 1.9:1 |
| | Total | 73,595 | 40.0 | | 4 | | 9,311 | 178,030 | 7,446 | 241,863 | 118,900 | 2,180,000 | 2.0:1 |
| | PUYALLUP BASIN | | | | | | | | | | | | |
| 7-1 | Algona-Pacific[4] | 6,457 | 12.0 | | | | 1,688 | 33,540 | 1,444 | 53,756 | 32,934 | 594,000 | 1.6:1 |
| 7-3 | Clear Creek[4] | 8,060 | 21.0 | | | | 2,364 | 38,320 | 6,587 | 135,302 | 104,621 | 1,901,000 | 1.3:1 |
| 0-38 | Hylebos Creek | 16,000 | 7.0 | | 1 | | 2,376 | 43,460 | 1,258 | 50,005 | 34,278 | 642,000 | 1.5:1 |
| 0-39 | Wapato Creek | 6,407 | 7.0 | | 1 | | 3,243 | 58,990 | 1,699 | 68,575 | 53,908 | 979,000 | 1.3:1 |
| 0-40 | Clover Creek[4] | 88,092 | 14.0 | | | | 4,990 | 86,400 | 805 | 74,320 | 45,421 | 856,000 | 1.6:1 |
| | Total | 125,016 | 61.0 | | 2 | | 14,661 | 260,710 | 11,793 | 381,958 | 271,162 | 4,972,000 | 1.4:1 |
| | WEST SOUND BASINS | | | | | | | | | | | | |
| 0-54 | Goldsborough Creek | 38,501 | 5.0 | | | 11,200 | 3,388 | 54,760 | 261 | 48,329[6] | 41,888 | 779,000 | 1.2:1 |
| 0-73 | Chimacum Creek | 22,326 | 16.0 | | 8 | 15[5] | 3,375 | 69,440 | 2,717 | 101,596 | 17,327 | 300,000 | 5.9:1 |
| | Total | 60,827 | 21.0 | | 8 | 11,215 | 6,763 | 124,200 | 2,978 | 149,925 | 59,215 | 1,079,000 | 2.5:1 |
| | GRAND TOTAL | 632,900 | 478.3 | 53.4 | 51 | 12,725 | 187,671 | 3,831,170 | 189,519 | 5,969,443 | 1,890,660 | 33,989,000 | 3.2:1 |

1 Flood damages based on historical averages. Base: 1967 prices.

2 Amortized at 4-5/8 percent for 100-years; operation and maintenance at adjusted normalized price. Allocation of costs and benefits to other possible purposes not fully evaluated.

3 Base: 1967 prices; operation and maintenance at adjusted normalized prices.

4 Part of the watershed.

5 Debris basin.

6 Contains $8,000 average annual benefit to industrial areas.

lands and to apply applicable conservation treatment measures. Proposals for higher levels of use, development, or protection are not included.

Acceleration of measures for rehabilitation, protection, and development of lands benefited by projects will be accomplished to take advantage of opportunities for improvement made possible by the projects and to add to the efficiency and security of project accomplishments.

In order that project planning and timely installation of interrelated features of these projects may proceed with maximum benefits, the Secretary of Agriculture may elect to request immediate Area-wide planning authorization by Congress of the watershed projects contained in the early action program of the Department of Agriculture (Table 2-20).

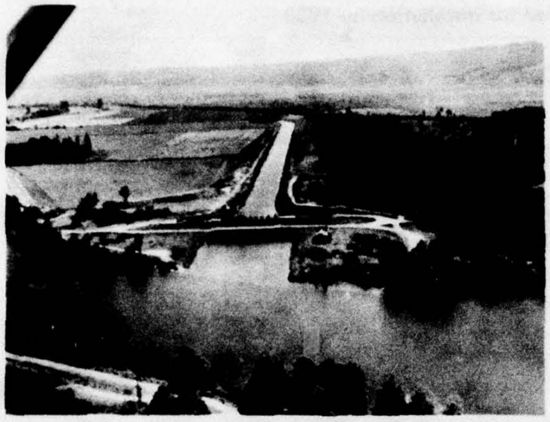


PHOTO 2-21. Marshland pumping piant for flood prevention and drainage nearing completion at Snohomish. Installation assistance was given by the State of Washington and the United States Department of Agriculture. (SCS)

The costs and benefits of the 25 early action projects are given in Table 2-20, and the types of improvements to be installed are summarized. The area included in these projects totals 632,900 acres.

Department of Agriculture projects to be installed during later time periods are summarized by the number of projects in each basin, with estimated installation costs, in Tables 2-21 and 2-22.

Watershed management program costs in the Puget Sound Area for the Department of Agriculture agencies are expected to approximate $153,511,000 during the early action period; $267,923,000 during the period 1980-2000; and $209,654,000 during the period 2000-2020, as shown under "Federal Costs" in Tables 2-15, 2-16, and 2-17. The total of $631,088,000 by the year 2020 represents on-going programs of these agencies, together with acceleration needed to accomplish the work.

In addition, the Department is expected to participate in cooperative soil surveys and cooperative sediment studies costing an additional estimated $5,225,000 prior to 1980. An additional share of the cost of continuing portions of these studies will extend beyond 1980. The totals do not include the cost of Federal-State cooperative research grants and similar expenses; nor costs of agencies having less than a major interest in watershed management.

**TABLE 2-21. Projects, by basin, recommended for installation in the 1980-2000 period**

| Basin | Number of Projects | Structural Measures Total Installation Cost (dollars) |
|---|---|---|
| Nooksack-Sumas | 7 | 5,950,000 |
| Skagit-Samish | 3 | 1,850,000 |
| Stillaguamish | 3 | 5,620,000 |
| Whidbey-Camano | 4 | 3,245,000 |
| Snohomish | 7 | 12,240,000 |
| Cedar | 3 | 3,810,000 |
| Green | 1 | 1,700,000 |
| Puyallup | 4 | 4,167,000 |
| Nisqually | 4 | 2,930,000 |
| Deschutes | 3 | 1,410,000 |
| West Sound | 12 | 8,055,000 |
| Elwha-Dungeness | 5 | 2,962,000 |
| San Juan | 3 | 2,736,000 |
| Total | 59 | 56,675,000 |

**TABLE 2-22. Projects, by basin, recommended for installation in the 2000-2020 period**

| Basin | Number of Projects | Structural Measures Total Installation Cost (dollars) |
|---|---|---|
| Nooksack-Sumas | 5 | 936,000 |
| Skagit-Samish | 5 | 1,460,000 |
| Stillaguamish | 3 | 1,310,000 |
| Whidbey-Camano | 0 | 0 |
| Snohomish | 1 | 100,000 |
| Cedar | 1 | 100,000 |
| Green | 1 | 100,000 |
| Puyallup | 0 | 0 |
| Nisqually | 1 | 100,000 |
| Deschutes | 0 | 0 |
| West Sound | 7 | 970,000 |
| Elwha-Dungeness | 2 | 300,000 |
| San Juan | 0 | 0 |
| Total | 26 | 5,376,000 |

# IMPACT OF PLAN

The objectives of Appendix XIV, Watershed Management, are to put before the public a plan for the development and management of the land and water resources of the Puget Sound Study Area. The plan is to manage, by regulation and development, the land and water resources under conditions of sustained use to best satisfy the needs and wants of an expected population of 6.8 million in the Area by the year 2020.

A planned density of urban development of not less than six persons per acre will reduce development and maintenance costs for the usual public services supplied within such areas, including streets, water supply, sewer lines, drainage, etc. Savings are conservatively estimated to be $5 billion in development costs and $50 million annually in operation and maintenance over the needs of unplanned urban development resulting from projecting present trends of such development through the study period. Expected *shifts* in land use as a result of the impact of the plan are shown in Table 2-23.

Orderly development of the Area will preserve many natural and aesthetic values and reduce damages caused by floods and sediment. The productive capacity of the good cropland can be greatly increased, thus preserving this industry and many of its environmental values, despite loss of less valuable agricultural lands to other purposes. Improved management of forest areas and elimination of waste can increase production of forest products by 50 percent by the year 2020 on the land remaining in forest. By judicious choice of land use, these productive values of cropland and forest can be attained without seriously involving the spatial needs of the projected population. Many environmental qualities can be retained and enhanced by protection and development of watershed lands.

Much benefit can be obtained by regulation of development as needed by the public interest. Other benefits are derived through installation of improvements by the private sector, or sponsored by the private sector, in installation of early action programs set forth in this Appendix. Investments required for the installation of these early action programs are justified by favorable ratios of benefits to costs without evaluation of many intangible and secondary benefits that will accrue.

The Drainage and Land Stabilization Technical Committee recommends implementation of this plan for overall watershed management.

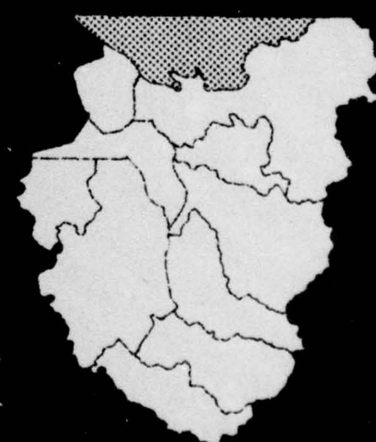
**TABLE 2-23. Shifts in land use, Puget Sound Area (thousands of acres)[1,2]**

| Basin | 1980 | | | | 2000 | | | | 2020 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Crop-land | Range Land | Forest Land | Built-up | Crop-land | Range Land | Forest Land | Built-up | Crop-land | Range Land | Forest Land | Built-up |
| Nooksack-Sumas | 137.5 | 11.6 | 609.6 | 33.6 | 137.5 | 11.6 | 609.6 | 33.6 | 139.0 | 11.6 | 608.1 | 33.6 |
| Skagit-Samish | 101.0 | 19.7 | 1,752.9 | 38.9 | 105.0 | 19.7 | 1,748.9 | 38.9 | 115.0 | 19.7 | 1,738.9 | 38.9 |
| Stillaguamish | 34.5 | 1.0 | 385.5 | 12.6 | 34.5 | 1.0 | 385.5 | 12.6 | 35.0 | 1.0 | 384.6 | 13.0 |
| Whidbey-Camano | 22.5 | 2.5 | 84.1 | 23.4 | 21.8 | 2.5 | 84.1 | 23.4 | 20.0 | 2.5 | 84.1 | 23.4 |
| Snohomish | 66.0 | 2.4 | 1,054.7 | 65.7 | 64.0 | 2.4 | 1,047.2 | 81.0 | 60.0 | 2.4 | 1,002.1 | 130.1 |
| Cedar | 14.0 | 1.1 | 152.8 | 196.0 | 12.0 | 1.1 | 114.6 | 236.2 | 7.5 | 1.1 | 51.8 | 303.5 |
| Green | 25.0 | 2.2 | 236.0 | 68.9 | 22.5 | 2.2 | 234.5 | 81.1 | 17.5 | 2.2 | 190.3 | 130.2 |
| Puyallup | 33.4 | 5.7 | 593.3 | 123.2 | 31.7 | 5.7 | 593.3 | 123.6 | 30.0 | 5.7 | 524.9 | 198.5 |
| Nisqually | 19.9 | 34.0 | 379.7 | 11.8 | 14.5 | 34.0 | 379.7 | 11.8 | 9.6 | 34.0 | 379.7 | 11.8 |
| Deschutes | 11.8 | 9.5 | 127.1 | 28.0 | 8.1 | 9.5 | 127.1 | 28.0 | 5.4 | 9.5 | 127.1 | 28.0 |
| West Sound | 43.1 | 5.1 | 1,123.7 | 106.4 | 41.6 | 5.1 | 1,123.7 | 106.4 | 40.0 | 5.1 | 1,123.7 | 106.4 |
| Elwha-Dungeness | 23.9 | 2.4 | 409.4 | 11.0 | 23.9 | 2.4 | 409.3 | 11.0 | 24.0 | 2.4 | 409.2 | 11.0 |
| San Juan | 20.0 | 9.1 | 70.6 | 11.9 | 21.0 | 9.1 | 69.6 | 11.9 | 22.0 | 9.1 | 68.6 | 11.9 |
| Total Area | 552.6 | 106.3 | 6,979.4 | 731.4 | 538.1 | 106.3 | 6,927.1 | 799.5 | 525.0 | 106.3 | 6,693.1 | 1,040.3 |

[1] Does not include 1,555,500 acres of salt water, 152,400 acres of fresh water, and 34,700 acres of unclassified land in 1980; 33,500 acres of unclassified land in 2000; and 39,700 acres of unclassified land in 2020.

[2] Unadjusted measurements for Puget Sound Area Study.

# Nooksack-Sumas Basins



# NOOKSACK-SUMAS BASINS

The Nooksack-Sumas Basins occupy most of the western portion of Whatcom County. The Nooksack is the largest river and drains an area of 760 square miles. The Sumas River drains 52 square miles into The Fraser River, and the Upper Chilliwack River drains 186 square miles into the Fraser River system in British Columbia. Coastal streams, such as California, Dakota, and Terrell Creeks, drain an area of 259 square miles into the Strait of Georgia. Total drainage area of the Nooksack-Sumas Basins is approximately 1,257 square miles.

## PRESENT STATUS

Population of the Basins in 1963 was 74,600. Projections show that the population in 1980 will be 91,600; in 2000, 123,500; and in 2020, 168,700. Density per acre figured on urban built-up and rural non-farm lands is 2.22 people per acre at present time.

Farming and forestry are the main users of land in the Basins. Forage production in support of a livestock industry is the largest type of farming. There are large amounts of strawberries and raspberries produced, and a limited acreage of potatoes usually used for seed. These crops, together with small acreages of canning peas and corn, create a diversity of farming enterprises. Total value of farm production is over $25 million annually. Forestry continues to be a major segment of agriculture, as 609,000 acres are presently in forest and associated open areas.

Farming, forestry, and fishing have long been the leading industries in the Basins. Recently, however, other industries have moved in. An aluminum reduction plant and an oil refinery are among the newest industries to be established. These, together with food processing plants, a pulp mill, and a cement plant make up the industrial complex of the Nooksack-Sumas Basins.

Salmon produced from the Nooksack River contribute significantly to the commercial and sport fisheries within Puget Sound, Strait of Juan de Fuca, and coastal ocean waters. The major fishing port at Bellingham provides a significant portion of the economy of the Basins. An important segment of the shellfish production occurs within these waters.

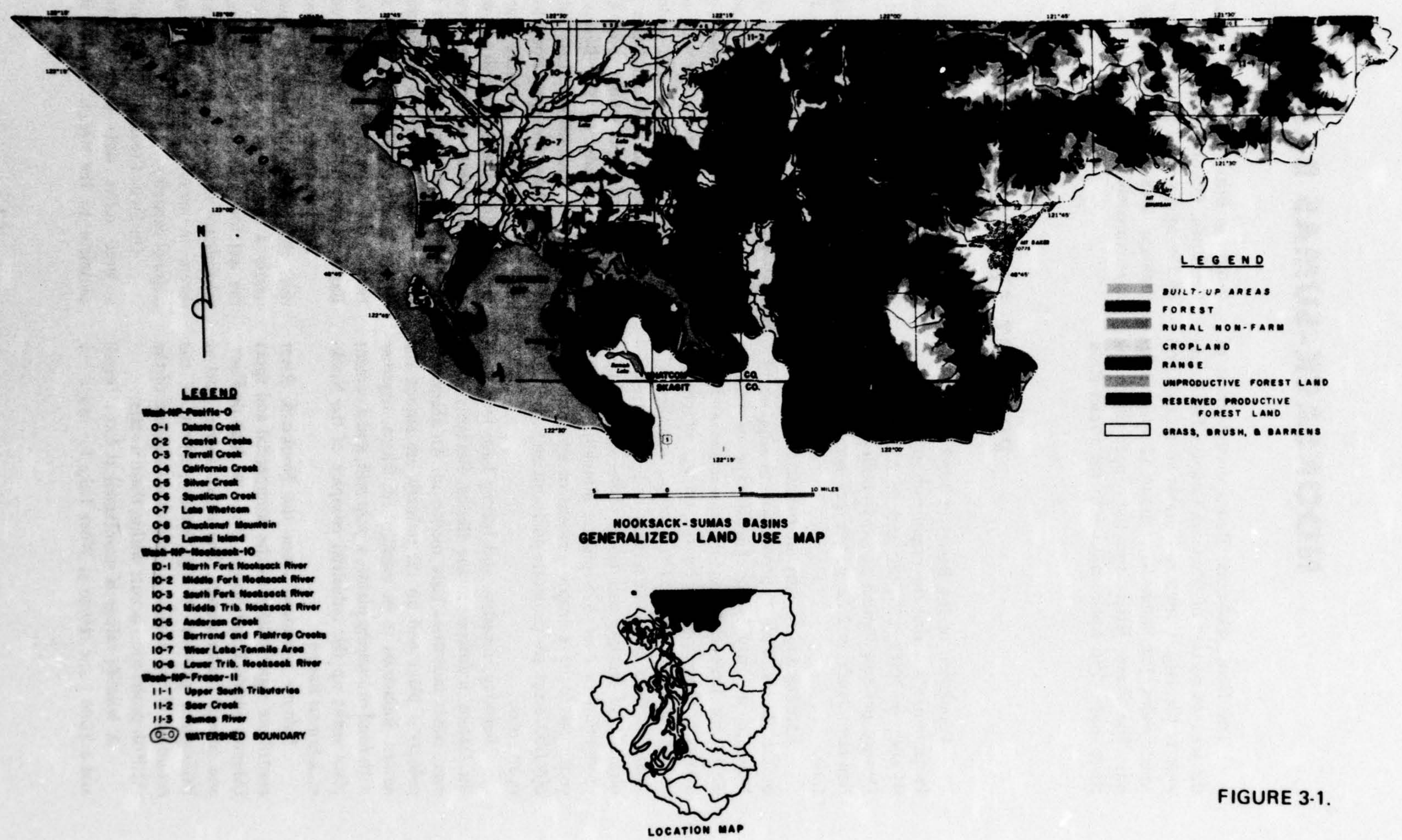
A wildlife refuge is maintained at Lake Terrell and a State game refuge at Wiser Lake for migratory waterfowl and other birds. Upland game in moderate amounts are found in the lowlands but are declining in numbers due to the shift from grain to grass on farmlands. Furbearing animals are found along streams and near swampy areas. Big game in considerable numbers are found in the forested mountain areas.

The Area with its miles of salt water shoreline in the west, mountainous area in the central and eastern portions, lakes and many miles of rivers and streams is well suited to provide a wealth of varied recreation opportunities. For example, the Heather Meadows area near Mount Baker is an outstanding scenic attraction and winter sports area.

The climate of the Basins is conducive to extremes of streamflows. Late fall and winter frequently produce damaging floodflows and conversely midsummer drouth produces low flow conditions which are detrimental to fish and wildlife, recreation, and to sanitation within the streams. Potential for development of streams and rivers is limited in many respects unless low flows can be augmented to some degree by structural measures and management practices. Low flow characteristics for streams in the Basin are given in Appendix III, Hydrology.

Some unfavorable conditions of stream and river channels in the Basins are partly the result of nearly a century of exploitation by man with only the last few years devoted to efforts to protect and rehabilitate the environment. Streambank erosion is severe in areas where sediment and debris reduce channel capacity.

On Swift Creek, a tributary of the Sumas River, a large active slide is contributing quantities of sediment to the stream. Smaller slides exist on the



LEGEND
BUILT-UP AREAS
FOREST
RURAL NON-FARM
CROPLAND
RANGE
UNPRODUCTIVE FOREST LAND
RESERVED PRODUCTIVE FOREST LAND
GRASS, BRUSH, & BARRENS
WHATCOM CO.
SKAGIT CO.
N
10 MILES
NOOKSACK-SUMAS BASINS
GENERALIZED LAND USE MAP
LEGEND
Wash-NP-Pacific-0
0-1 Dakota Creek
0-2 Coastal Creeks
0-3 Terrell Creek
0-4 California Creek
0-5 Silver Creek
0-6 Squalicum Creek
0-7 Lake Whatcom
0-8 Chuckanut Mountain
0-9 Lummi Island
Wash-NP-Nooksack-10
10-1 North Fork Nooksack River
10-2 Middle Fork Nooksack River
10-3 South Fork Nooksack River
10-4 Middle Trib. Nooksack River
10-5 Anderson Creek
10-6 Bertrand and Fishtrap Creeks
10-7 Wiser Lake-Tenmile Area
10-8 Lower Trib. Nooksack River
Wash-NP-Fraser-11
11-1 Upper South Tributaries
11-2 Saar Creek
11-3 Sumas River
WATERSHED BOUNDARY
LOCATION MAP


FIGURE 3-1.

North Fork of the Nooksack and on other tributary streams. Debris dams from previous logging operations are present on many tributaries and are a hazard when high flows occur.

A project on Saar Creek has been completed in these Basins (Figure 3-1, Watershed Area 11-2). This project is basically for floodwater reduction and drainage control.

## PRESENT LAND USE

The bench terrace and bottom land areas of the Nooksack-Sumas Basins provide the largest single block of land suited for cropland within the Puget Sound Area. The equitable marine climate is conducive to the production of a wide variety of crops. The productive potential of the area is great, but flood and drainage conditions make works of improvement necessary before this region reaches its potential (see Figure 3-1). The ownership distribution of the Basins' lands are shown on Figure 3-2.

The broad categories of land use are given in Table 3-1. No attempt is made here to quantify multiple use management of lands such as for game habitat, recreation, water quality, or low flow augmentation.

**TABLE 3-1. Present land use by sub-basins[1]**

| Land Use | Nooksack River Basin | Fraser-Sumas River Basins | Puget Sound Drainages | Total |
|---|---|---|---|---|
| | (acres) | (acres) | (acres) | (acres) |
| Cropland | 76,937 | 21,924 | 38,631 | 137,492 |
| Rangeland | 4,517 | 1,032 | 6,051 | 11,600 |
| Forest[2] | 388,784 | 127,256 | 93,541 | 609,581 |
| Rural non-farm | 5,972 | 920 | 5,777 | 12,669 |
| Urban built-up | 4,364 | 788 | 15,744 | 20,896 |
| Fresh water | 5,621 | 384 | 6,124 | 12,129 |
| Total | 486,195 | 152,304 | 165,868 | 804,367 |

[1] Unadjusted measurements 1966 for Puget Sound study. Tabulations by ADP. First three figures are significant figures for acreages.

[2] Includes non-forested land normally associated with forest.

## SOILS

A medium intensity soil survey is available for most lands outside the national forest and ational park boundaries. Lands within the national forests and national parks were mapped from reconnaissance type survey.

The mapping units are discussed in the soil survey report for Whatcom county and their locations are shown on maps. The soil survey report is available in libraries and in local offices of the United States Department of Agriculture.

The principal properties of each soil series are tabulated in Exhibit 1, Table 6 of this Appendix. Interpretations of data for each soil series are provided in subsequent tables of the Exhibit.

The total land area of 792,000 acres in the Nooksack-Sumas Basins has a medium intensity survey on 516,500 acres and a low intensity survey on 275,500 acres. Of the 516,500 acres, 287,500 acres are classified in Land Capability Classes II through VI, 226,000 acres are in Class VII, and 3,000 acres are Class VIII (See Figure 3-3).

Lands in Land Use Capability Class II through VI (287,500 acres) have the greatest potential for development; i.e., changed use or improved use. Land Use Capability Classes II, III, and IV may be suited for either crops or urban uses, and Class VI has potential for urban development. Most of the Class II and Class III lands in these Basins are subject to flooding and have wetness conditions which present hazards for many developed uses. Class VII is expected to be largely limited to forest use and Class VIII for recreation or aesthetic use.

The soil types in the Area having a medium intensity survey have been classified into land use capability classes and their primary and secondary subclasses, and capability units (see Exhibit 1, Tables 9 and 10). Lands having only reconnaissance surveys are roughly grouped into capability classes.

Tables 3-2 and 3-3 which follow give a tabulation of capability subclasses and specific wetness conditions for surveyed lands in these basins.

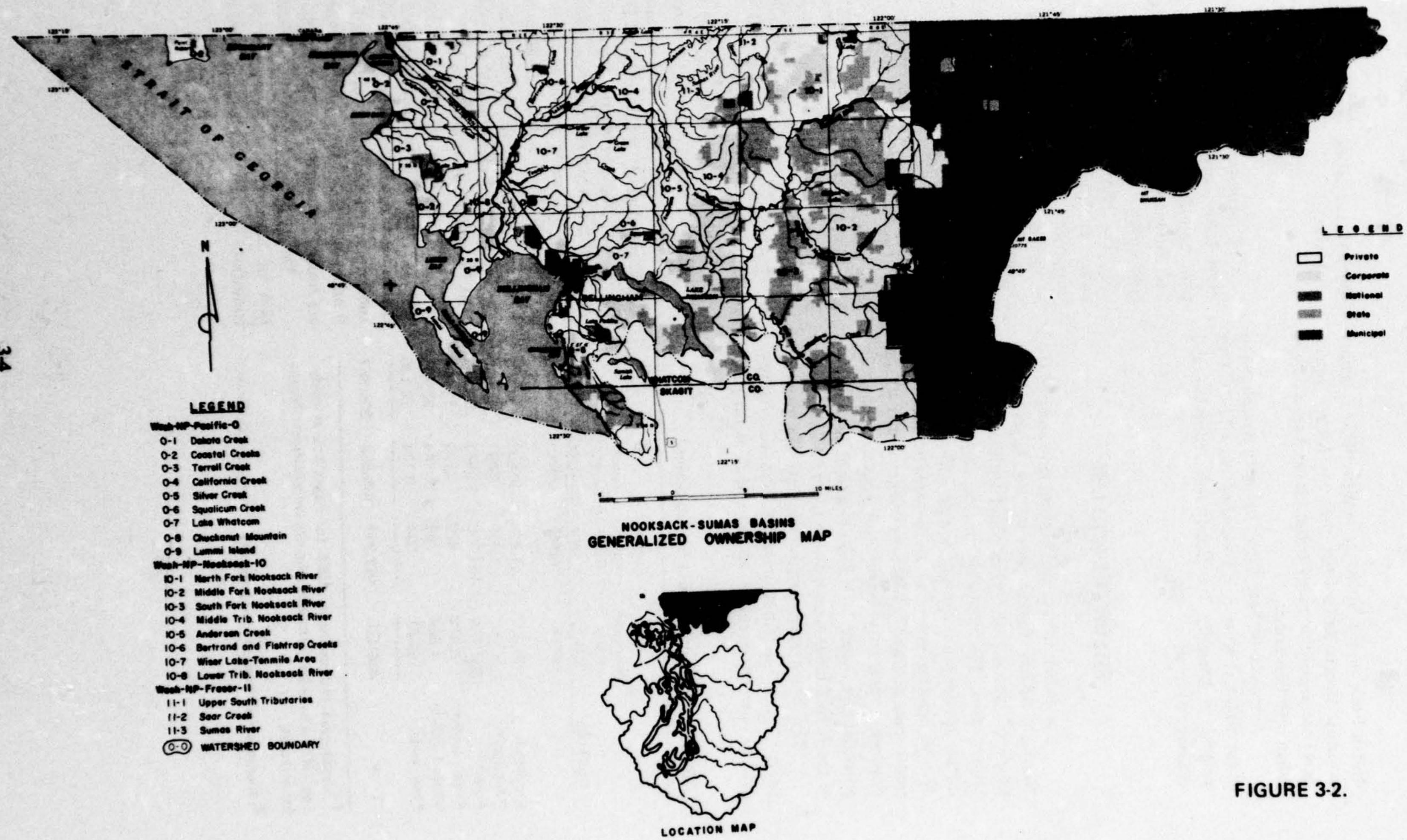

STRAIT OF GEORGIA
WHATCOM CO.
SKAGIT CO.
LEGEND
Private
Corporate
National
State
Municipal
N
10 MILES
NOOKSACK-SUMAS BASINS
GENERALIZED OWNERSHIP MAP
LEGEND
Wash-NP-Pacific-0
0-1 Dakota Creek
0-2 Coastal Creeks
0-3 Terrell Creek
0-4 California Creek
0-5 Silver Creek
0-6 Squalicum Creek
0-7 Lake Whatcom
0-8 Chuckanut Mountain
0-9 Lummi Island
Wash-NP-Nooksack-10
10-1 North Fork Nooksack River
10-2 Middle Fork Nooksack River
10-3 South Fork Nooksack River
10-4 Middle Trib. Nooksack River
10-5 Anderson Creek
10-6 Bertrand and Fishtrap Creeks
10-7 Wiser Lake-Tenmile Area
10-8 Lower Trib. Nooksack River
Wash-NP-Fraser-11
11-1 Upper South Tributaries
11-2 Saar Creek
11-3 Sumas River
WATERSHED BOUNDARY
LOCATION MAP

FIGURE 3-2.

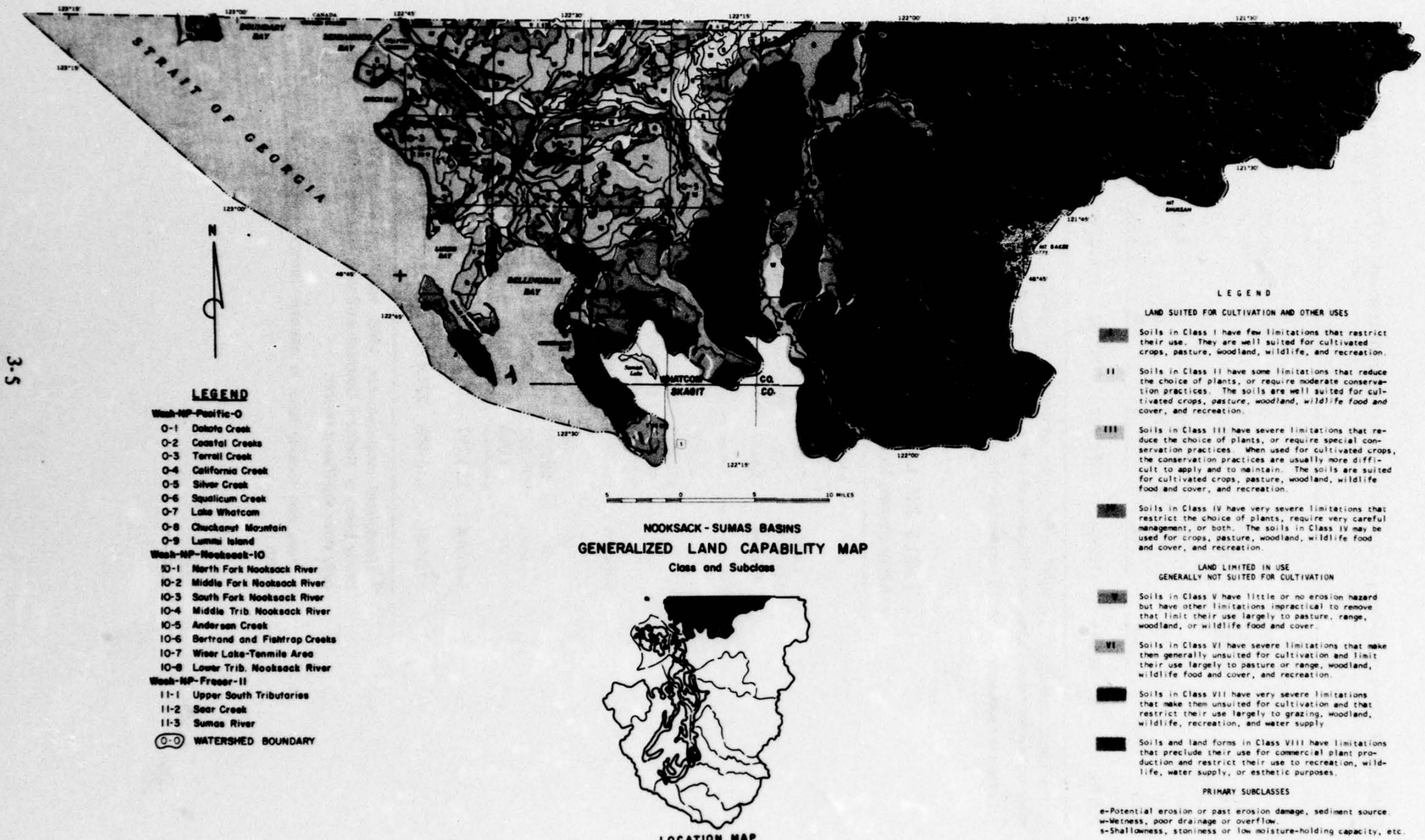

STRAIT OF GEORGIA
BOUNDARY BAY
BELLINGHAM BAY
WHATCOM CO.
SKAGIT CO.
NOOKSACK - SUMAS BASINS
GENERALIZED LAND CAPABILITY MAP
Class and Subclass
LOCATION MAP
LEGEND
Wash-NP-Pacific-O
0-1 Dakota Creek
0-2 Coastal Creeks
0-3 Terrell Creek
0-4 California Creek
0-5 Silver Creek
0-6 Squalicum Creek
0-7 Lake Whatcom
0-8 Chuckanut Mountain
0-9 Lummi Island
Wash-NP-Nooksack-10
10-1 North Fork Nooksack River
10-2 Middle Fork Nooksack River
10-3 South Fork Nooksack River
10-4 Middle Trib. Nooksack River
10-5 Anderson Creek
10-6 Bertrand and Fishtrap Creeks
10-7 Wiser Lake-Tenmile Area
10-8 Lower Trib. Nooksack River
Wash-NP-Fraser-11
11-1 Upper South Tributaries
11-2 Sear Creek
11-3 Sumas River
0-0 WATERSHED BOUNDARY
LEGEND
LAND SUITED FOR CULTIVATION AND OTHER USES
Soils in Class I have few limitations that restrict their use. They are well suited for cultivated crops, pasture, woodland, wildlife, and recreation.
II Soils in Class II have some limitations that reduce the choice of plants, or require moderate conservation practices. The soils are well suited for cultivated crops, pasture, woodland, wildlife food and cover, and recreation.
III Soils in Class III have severe limitations that reduce the choice of plants, or require special conservation practices. When used for cultivated crops, the conservation practices are usually more difficult to apply and to maintain. The soils are suited for cultivated crops, pasture, woodland, wildlife food and cover, and recreation.
Soils in Class IV have very severe limitations that restrict the choice of plants, require very careful management, or both. The soils in Class IV may be used for crops, pasture, woodland, wildlife food and cover, and recreation.
LAND LIMITED IN USE
GENERALLY NOT SUITED FOR CULTIVATION
V Soils in Class V have little or no erosion hazard but have other limitations impractical to remove that limit their use largely to pasture, range, woodland, or wildlife food and cover.
VI Soils in Class VI have severe limitations that make them generally unsuited for cultivation and limit their use largely to pasture or range, woodland, wildlife food and cover, and recreation.
Soils in Class VII have very severe limitations that make them unsuited for cultivation and that restrict their use largely to grazing, woodland, wildlife, recreation, and water supply.
Soils and land forms in Class VIII have limitations that preclude their use for commercial plant production and restrict their use to recreation, wildlife, water supply, or esthetic purposes.
PRIMARY SUBCLASSES
e-Potential erosion or past erosion damage, sediment source.
w-Wetness, poor drainage or overflow.
s-Shallowness, stoniness or low moisture-holding capacity, etc.

FIGURE 3-3.

TABLE 3-2. Land conditions by capability classes in Nooksack-Sumas Basins (in acres) [1]

| Class | Subclasses [2] s | ew | es | we | ws | se | sw | Class Total |
|---|---|---|---|---|---|---|---|---|
| II | 2,035 | 0 | 0 | 0 | 40,796 | 0 | 0 | 42,831 |
| III | 12,447 | 11,486 | 255 | 11,762 | 80,902 | 0 | 0 | 116,852 |
| IV | 19,876 | 47,144 | 18,993 | 0 | 7,554 | 4,890 | 9 | 98,546 |
| V | 0 | 0 | 0 | 0 | 240 | 0 | 0 | 240 |
| VI | 1,337 | 13,805 | 9,320 | 0 | 4,144 | 366 | 0 | 28,972 |
| VII | 0 | 726 | 225,224 | 0 | 2 | 0 | 0 | 225,952 |
| VIII | 248 | 443 | 0 | 0 | 2,402 | 0 | 0 | 3,093 |
| TOTAL | 35,943 | 73,604 | 253,792 | 11,762 | 136,040 | 5,336 | 9 | 516,486 |

[1] Unadjusted measurements, 1966, for Puget Sound Area Study, based on National Cooperative Soil Survey maps. Read only three significant figures. Does not include land within national forests and national parks.

[2] Letters for subclasses denote hazards or conditions that affect land use and treatment: e—erosion; w—wetness; s—soil.

TABLE 3-3. Land with wetness condition by capability classes, Nooksack-Sumas Basins (in acres) [1]

| Land Capability Classes | All land in basins[2] Total All Land | With Wetness Condition | Cropland in basins Total Cropland (est) | Cropland With Wetness Condition (est.) |
|---|---|---|---|---|
| II | 42,831 | 40,796 | 40,689 | 38,756 |
| III | 116,852 | 104,150 | 86,959 | 66,428 |
| IV | 98,546 | 54,707 | 9,844 | 5,465 |
| Subtotal | 258,229 | 199,653 | 137,492 | 110,649 |
| V | 240 | 240 | 0 | 0 |
| VI | 28,972 | 17,949 | 0 | 0 |
| VII | 225,952 | 728 | 0 | 0 |
| VIII | 3,093 | 2,845 | 0 | 0 |
| Subtotal | 258,257 | 21,762 | 0 | 0 |
| TOTAL | 516,486 | 221,415 | 137,492 | 110,649 |

[1] Unadjusted measurements, 1966, for Puget Sound Area Study based on National Cooperative Soil Survey maps. Read only three significant figures.

[2] Does not include land in national forests and national parks.

# PRESENT AND FUTURE NEEDS

## EVALUATION OF PRESENT SITUATION

In the Nooksack-Sumas Basins, three broad categories of needs—protection from floodwater damage, measures for watershed protection and rehabilitation, and measures for water managment—are present in varying degrees of intensity according to land use. About 137,492 acres are devoted to cropland use at the present time; 609,581 acres are in forest (including some areas of non-forested land); 11,600 acres rangeland; and 33,565 acres are in more intensive uses. According to Appendix VII, Irrigation, 38,400 acres were under irrigation in 1966.

## ESTIMATED FUTURE NEEDS

Determination of needs is made on the basis of multiple-use management and the categories of floodwater damage reduction. Watershed protection and rehabilitation measures, and water management, contain the pracitices needed for development under the concept. Development needed in forestry and farming is to keep pace with other needs as the population increases and reach the level required by 2020.

Future needs are given in acres of land to be treated. Intensity or degree of practice application will increase with use. Management practices for enhancement of multiple-use objectives may require several practices on the same acre of land. A partial listing of practices used is given in Table 2-18 and 2-19 in the Puget Sound Area section of this Appendix under Means to Satisfy Needs.

The projected rapid rise in population, with its requirements for space, recreation, and other land and water needs, makes it necessary to initiate an early action program of development to avoid costly misuse of the land resource. An obvious need in these Basins is for improved floodwater damage reduction on the Lower Nooksack flood plain as described in Appendix XII, Flood Control, and for flood prevention and drainage facilities to be installed on eight watersheds considered to be in need of improvements to accommodate orderly development of the basins. Details of these early action projects are found in the Means to Satisfy Needs section.

Projections indicate the Nooksack-Sumas Basin will remain, for the most part, agricultural with some industrial development taking place in the western part of the Basins. The estimated number of acres, according to land use, that will require protective and development measures by the years 1980, 2000, and 2020 are tabulated in Table 3-4. The same land area may require more than one of these practices.

**TABLE 3-4. Future needs for watershed management[1]**

| Year | Floodwater Damage[2] Reduction[3] (acres) | Watershed Protection & Rehab.[3] (acres) | Drainage Improvement[3] (acres) | Irrigation Development[4] (acres) |
|---|---|---|---|---|
| Cropland | | | | |
| 1980 | 97,539 | 149,100[5] | 55 ,378 | 60,000 |
| 2000 | 97,539 | 149,100[5] | 92,297 | 80,000 |
| 2020 | 97,539 | 150,600[5] | 1 23,062[6] | 115,000 |
| Intensive Land Use | | | | |
| 1980 | 15,520 | 33,565 | 33,565 | 0 |
| 2000 | 15,520 | 33,565 | 33,565 | 0 |
| 2020 | 15,520 | 33,565 | 33,565 | 0 |
| Forested Land[7] | | | | |
| 1980 | 0 | 609,573 | 0 | 0 |
| 2000 | 0 | 609,573 | 0 | 0 |
| 2020 | 0 | 608,073 | 0 | 54,500[8] |

1 Acreages derived by map measurements and ADP tabulation for the PS&AW study. Other potential not tabulated. Unrounded figures do not denote accuracy beyond the first three significant figues.

2 Includes overbank flooding of main streams.

3 Needed for full agricultural development (see Appendix V, Water Related Land Resources, chapter 2, Agriculture).

4 According to Appendix VII, Irrigation, there were 38,400 acres (using 73,344 acres feet of water) irrigated in 1966. Irrigation Appendix projections show 58,400 acres irrigated by 1980; 78,400 acres by 2000; and 78,400 acres by 2020.

5 Includes 11,600 acres of rangeland.

6 Does not agree with table 3 due to land use changes during time lapse.

7 Includes non-forested land commonly associated with forested areas.

8 Potential irrigation of forests (see Appendix V, chapter 3, Forestry).

Table 3-5 shows drainage groups in the watersheds of the Nooksack-Sumas Basins, with the acreage of land falling into each group. From this and other data the drainage needs for expected land uses in the Basins are derived.

**TABLE 3-5. Drainage groups in Nooksack-Sumas Basins[1] (in acres)[2]**

| LINE | Watershed Area No.[3] | River Basins And Watersheds | 01 | 02 | 03 | 04 | 05 | 06 | 07 | 08 | 09 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Nooksack River Basin | | | | | | | | | | | | | | | | | |
| 1 | 10-1 | N. Fork Nooksack R. | 741 | 0 | 27 | 0 | 0 | 390 | 0 | 0 | 1,211 | 0 | 986 | 125 | 0 | 0 | 0 | 2,165 | 5,645 |
| 2 | 10-2 | Middle Fork " " | 277 | 0 | 69 | 0 | 0 | 151 | 0 | 0 | 45 | 0 | 320 | 25 | 0 | 0 | 0 | 424 | 1,311 |
| 3 | 10-3 | S. Fork " " | 5,641 | 0 | 434 | 0 | 0 | 381 | 0 | 0 | 436 | 16 | 1,488 | 32 | 0 | 32 | 0 | 2,678 | 11,138 |
| 4 | 10-4 | Middle Trib." " | 4,013 | 0 | 513 | 154 | 0 | 57 | 0 | 5 | 8,451 | 186 | 591 | 0 | 10 | 0 | 0 | 3,218 | 17,198 |
| 5 | 10-5 | Anderson Creek[4] | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 6 | 10-6 | Bertrand-Fishtrap Cr. | 1,169 | 0 | 3,396 | 184 | 0 | 327 | 0 | 4,794 | 4,715 | 0 | 9 | 553 | 1,374 | 0 | 0 | 517 | 17,138 |
| 7 | 10-7 | Wiser Lake-Tenmile A. | 2,413 | 0 | 4,901 | 454 | 0 | 0 | 0 | 3,356 | 12,248 | 180 | 108 | 313 | 719 | 0 | 0 | 1,533 | 26,225 |
| 8 | 10-8 | Lower Tribs. Nook. R. | 5,866 | 0 | 888 | 0 | 0 | 188 | 0 | 1,265 | 7,569 | 212 | 0 | 141 | 412 | 0 | 0 | 642 | 17,183 |
| 9 | | Total | 20,120 | 0 | 10,228 | 792 | 0 | 1,494 | 0 | 9,420 | 34,675 | 594 | 3,502 | 1,289 | 2,515 | 32 | 0 | 11,177 | 95,838 |
| | | Fraser River Basin | | | | | | | | | | | | | | | | | |
| 10 | 11-1 | Upper South Tribs. | 0 | 0 | 6 | 0 | 0 | 24 | 0 | 0 | 69 | 0 | 77 | 0 | 0 | 0 | 0 | 0 | 176 |
| 11 | 11-2 | Saar Creek | 2,630 | 0 | 192 | 0 | 0 | 130 | 0 | 0 | 868 | 0 | 765 | 37 | 0 | 0 | 0 | 601 | 5,223 |
| 12 | 11-3 | Sumas River | 9,732 | 0 | 1,970 | 40 | 0 | 441 | 0 | 0 | 3,773 | 377 | 1,277 | 458 | 0 | 262 | 0 | 2,435 | 20,765 |
| 13 | | Total | 12,362 | 0 | 2,168 | 40 | 0 | 595 | 0 | 0 | 4,710 | 377 | 2,119 | 495 | 0 | 262 | 0 | 3,036 | 26,164 |
| | | Puget Sound Drainages | | | | | | | | | | | | | | | | | |
| 14 | 0-1 | Dakota Creek | 175 | 0 | 243 | 0 | 0 | 66 | 0 | 3,265 | 8,181 | 337 | 693 | 26 | 1,456 | 0 | 462 | 0 | 14,904 |
| 15 | 0-2 | Coastal Creeks | 446 | 0 | 298 | 0 | 0 | 151 | 0 | 0 | 11,004 | 284 | 0 | 268 | 0 | 0 | 0 | 15 | 12,467 |
| 16 | 0-3 | Terrell Creek | 36 | 0 | 205 | 0 | 0 | 55 | 0 | 0 | 8,278 | 147 | 0 | 36 | 0 | 0 | 0 | 0 | 8,757 |
| 17 | 0-4 | California Creek | 407 | 0 | 863 | 0 | 0 | 101 | 0 | 2,209 | 6,107 | 1,748 | 0 | 28 | 398 | 0 | 27 | 7 | 11,895 |
| 18 | 0-5 | Silver Creek | 827 | 0 | 201 | 0 | 0 | 153 | 0 | 89 | 7,862 | 84 | 0 | 20 | 110 | 0 | 0 | 37 | 9,383 |
| 19 | 0-6 | Squalicum Creek | 0 | 0 | 129 | 0 | 0 | 155 | 0 | 0 | 13,692 | 367 | 702 | 0 | 8 | 0 | 0 | 0 | 15,053 |
| 20 | 0-7 | Lake Whatcom | 180 | 0 | 212 | 0 | 0 | 164 | 0 | 0 | 7,895 | 292 | 4,240 | 5 | 0 | 68 | 0 | 0 | 13,056 |
| 21 | 0-8 | Chuckanut Mountain | 223 | 0 | 104 | 0 | 0 | 76 | 0 | 0 | 1,935 | 705 | 5,211 | 79 | 0 | 11 | 0 | 26 | 8,370 |
| 22 | 0-9 | Lummi Island | 120 | 0 | 14 | 0 | 0 | 0 | 0 | 0 | 5,063 | 65 | 0 | 29 | 0 | 0 | 0 | 0 | 5,291 |
| 23 | | Total | 2,414 | 0 | 2,270 | 0 | 0 | 921 | 0 | 5,563 | 70,017 | 4,029 | 10,846 | 491 | 1,972 | 79 | 489 | 85 | 99,176 |
| 24 | | Grand Total | 34,896 | 0 | 14,666 | 832 | 0 | 3,010 | 0 | 14,983 | 109,402 | 5,000 | 16,467 | 2,275 | 4,487 | 373 | 489 | 14,298 | 221,178 |

[1] Descriptions of drainage groups are found in the Means to Satisfy Needs section of the Area report.

[2] Unadjusted measurements, 1966, for Puget Sound Area Study. Tabulations by ADP. Read three significant figures.

[3] See Figure 3-1 for location.

[4] Included in 10-4.

# MEANS TO SATISFY NEEDS

The objectives of the plan for watershed management are to develop the Area's resources to achieve its potential production of food and fiber as economically justified, to preserved and enhance fish, wildlife, and recreation values in accord with the Fish and Wildlife, and Recreation Appendices, to provide

Projections indicate that by the year 2020 population in these basins will be 168,700. The means to be used to achieve the development necessary to meet the needs of the expected population consist of programs for protection and development of the land and water resources of the Basins. The program includes projects for structural works where needed. The wise use and development of these resources can supply the spatial needs and aesthetic wants of the growing population in the Basins. The needs as developed in other appendices have been considered in this appendix relating to the land and water resources of the Nooksack-Sumas Basins.

for development of urban areas not subject to floodwater hazard, and to provide spatial needs in keeping with aesthetic qualities of the Area. These objectives will be carried out by various agencies of the Federal and State governments working in close cooperation with each other and with private sources.

## Land Use

Table 3-1 in Present Status indicates by subbasins the present land use. Table 3-6 summarizes by time periods the estimated future use of the land.

## Flooding

Floodwater damage must be prevented to the extent hazard remaining does not materially exceed other risks before further development becomes practical. Loss is limited by restricting intensive use of land in hazardous areas, followed by feasible damage prevention and enhancement measures for suitable land use.

**TABLE 3-6. Estimated future land use**

| Year | Crop-land (acres) | Range-land (acres) | Forest[1] (acres) | Urban Built-up[2] (acres) | Fresh Water (acres) | Total (acres) |
|---|---|---|---|---|---|---|
| 1980 | 137,500 | 11,600 | 609,573 | 33,565 | 12,129 | 804,367 |
| 2000 | 137,500 | 11,600 | 609,573 | 33,565 | 12,129 | 804,367 |
| 2020 | 139,000 | 11,600 | 608,073 | 33,565 | 12,129 | 804,367 |

1 Includes non-forested land normally associated with forest.

2 Rural non-farm is assumed to be all urban by 1980. Built-up based on average urban density of six persons per acres.

Kinds and intensity of management are fitted to capability of land and to use. Programs and projects are planned to stabilize land and benefit most study functions.

## PLAN OF DEVELOPMENT

This plan to provide for the satisfaction of needs as brought out in the Needs discussion, will utilize the program and project approach, as explained *in the Puget Sound Area section. The plan will* guide the development of the resources of the Nooksack-Sumas Basins to provide for spatial and production requirements for the expected population of its service area to the year 2020. The Nooksack-Sumas Basins offer many opportunities for projects and programs that could maintain and increase fish, wildlife, and recreation areas.

### Early Action Projects

Several projects will be proposed prior to 1980 to remedy existing floowater and drainage problems *and to develop lands toward their potential for* continued use. Following are descriptions of projects in the early action plan:

**TABLE 3-7. Costs and benefited areas, early action projects recommended for installation by 1980**

| Watershed Area No. and Name[1] | Project Area (acres) | Project Structural Measures Cost[2] (dollars) | Flood-water Protec-tion (acres) | Drainage Improve-ment (acres) |
|---|---|---|---|---|
| 10-4 Middle Nooksack Tributaries[3] | 6,750 | 986,000 | 3,199 | 4,582 |
| 10-6 Fishtrap-Bertrand Cr. | 23,914 | 1,854,000 | 13,159 | 13,508 |
| 10-7 Wiser Lake | 38,305 | 2,448,000 | 14,791 | 18,832 |
| 10-8 Lower Nooksack Tributaries | 19,835 | 2,370,000 | 10,499 | 12,559 |
| 11-3 Sumas River | 33,079 | 1,241,000 | 14,509 | 14,692 |
| 0-1 Dakota Creek | 20,314 | 430,000 | 593 | 3,118 |
| 0-4 California | 14,192 | 471,000 | 1,397 | 3,500 |
| 0-5 Silver (Marietta) Cr. | 10,866 | 1,173,00 | 2,736 | 4,999 |
| Total | 167,255 | 10,973,000 | 60,883 | 75,790 |

1 See Figure 3-1 for location.

2 1967 prices.

3 Part of watershed.

**Middle Nooksack Tributaries Watershed Area 10-4, Figure 3-1** is located on both sides of the Nooksack River between Deming and Lynden. It is a long, narrow watershed and consists of many minor streams which contribute to the Nooksack. Flow and water management problems exist principally on the flood plain of the Nooksack, while erosion, pollution, sedimentation, and other problems exist throughout the watershed.

The principal cultivated areas are on the Nooksack flood plain and the principal crops consist of grass pasture, vegetables, potatoes, cane fruits, and strawberries.

About 20 percent of the watershed has a forest cover. There are some fringes of hardwood along the main stem of the Nooksack; otherwise, the forest is concentrated in the uplands with young mixed stands of Douglas-fir and red alder. Although the timber harvest from these tracts may not be significant, the importance of protecting watershed resources, wildlife habitat, outdoor recreation environment, and their aesthetic values must be considered.

The project is designed for flood prevention on agricultural and urban areas and drainage of agricultural lands. The area included in this watershed contains 6,750 acres, of which there are 5,218 acres of cropland, 786 acres of forest, 550 acres of rural non-farm and urban, and 196 acres of miscellaneous uses.

The works of improvement will consist of 7 miles of improved and stabilized channels, one outlet structure consisting of floodgates and pumps, and the necessary dike modification and strengthening to insure the satisfactory operation of these facilities. Coordination in the installation of the USDA project and Corps of Engineers early action program will result in the enhancement of benefits from each project.

Installation cost is estimated to be $985,545, of which the Federal share is $741,650, and the local share is $243,895. Benefits from damage reduction and drainage are estimated to provide a benefit cost ratio of 2.4 to 1. To achieve benefits made possible by the structural works and other management during a 15-year period, local interests will install necessary land treatment measures for erosion control and flood management costing approximately $371,002, drainage measures expected to cost $857,155, and forest protection and management practices costing $15,396, for a total of $1,244,533. The total cost of installing the structural measures and the land treatment measures is estimated at $2,230,098.

**Fishtrap-Bertrand Creeks Watershed Area 10-6, Figure 3-1** is located partly in Canada and partly in the United States. Runoff water flows out of Canada into northern Whatcom County, north of the city of Lynden. This water, along with excess rainfall in the American portion, causes flood, erosion, and drainage problems. The Canadian area, of approximately 24,000 acres, is being urbanized and floodflows from this area are becoming larger and more frequent. A large part of the American section is in cultivated crops, mostly pasture and grass.

About 12 percent of the watershed is forest cover, most of which is in the Bertrand Creek drainage. Forest land, composed of mixed Douglas-fir and red alder, is concentrated along Bertrand Creek in the northwest corner of the watershed. A 240-acre tract has been set aside as Berthusen Memorial Park. Other areas may be kept in forest as much for their aesthetic values as for the economic return from a timber harvest.

A project is proposed for flood prevention on agricultural and urban areas and drainage of agricultural lands. The watershed area is 23,914 acres, of which 18,501 acres are cropland, 3,237 acres are forest, 1,867 acres rural non-farm and urban, and 309 acres miscellaneous uses.

Improvement consists of land treatment measures on the watershed lands and structural measures consisting of 37 miles of improved and stabilized channels, two outlet structures consisting of floodgates and pumps, and the necessary dike modifications and strengthening to insure the satisfactory operation of these facilities.

Installation cost is estimated to be $1,854,000 of which the Federal share is $1,131,985, and the local share is $722,015. Benefits from damage reduction and drainage will provide a benefit-cost ratio of 4.2 to 1. To achieve benefits made possible by the structural works and other management during a 15-year period, local interests will install necessary land treatment measures for erosion control and flood management, costing approximately $1,315,418, drainage measures expected to cost $2,737,436, and forest protection and management practices costing $67,524, for a total of $4,120,378. The total cost of installing the structural measures and the land treatment measures is $5,974,378.

**Wiser Lake Watershed Area 10-7, Figure 3-1** is located between Bellingham and Lynden in northwest

Whatcom County. The area is principally agricultural. The elevations are typical of low coastal plains, and the topography is gently rolling. About 20 percent of the watershed is forest covered, mainly in red alder and paper birch with some isolated tracts of Douglas-fir. The tracts are scatttered throughout the watershed. There is no steep ground so land stability problems are minor. These tracts have some value as a source of woodcrops, but their main value is for wildlife habitat, recreation, and landscape enjoyment.

A project is proposed for flood prevention on agricultural and urban areas and drainage of agricultural lands. The watershed area contains 38,305 acres, of which 27,265 acres are cropland. 8,061 acres are forest, 1,577 acres rural non-farm and urban, and 1,402 acres miscellaneous uses.

The Wiser Lake watershed area consists of four separate minor streams which require structural measures and land treatment. The Scott Ditch in the northernmost portion of the watershed consists of 9 miles of improved channel and one outlet structure. The outlet structure would consist of floodgates and pumps. Wiser Lake improvement consists of 4 miles of improved channel, an improved outlet to the Nooksack River, and two small pumping installations. An unnamed stream in sections 15 and 16 would have 2 miles of improved channels and an outlet structure consisting of floodgates and pumps. Tenmile and Fourmile Creeks require 17 miles of improved channels and one reservoir for floodwater storage and recreation.

Installation cost is estimated to be $2,448,430, of which the Federal share is $1,767,520, and the local share is $680,910. Benefits from damage reduction and drainage will provide a benefit-cost ratio of 4.1 to 1. To achieve benefits made possible by the structural works and other management during a 15-year period, local interests will install necessary land treatment measures for erosion control and flood management costing approximately $1,938,523, drainage measures expected to cost $3,693,056, and forest protection and management practice costing $168,153, for a total of $5,799,741. The total cost of installing the structual measures and the land treatment measures is $8,248,171.

**Lower Nooksack Tributaries Watershed Area 10-8, Figure 3-1** is the area north and west of the Nooksack River in the vicinity of Ferndale and tributary to the Nooksack and the Red (or Lummi) Rivers. It is located about 10 miles northwest of Bellingham. The river flood plain is a level, fertile, agricultural area used for production of cultivated annual crops. The gently rolling area above the flood plain produces mostly grass or forest.

About 20 percent of the watershed is forest of small hardwood, principally red alder. Most of this is found on the Lummi Indian Reservation in the southern end of the watershed. Woodlands generally have low value timber. Their future use may be more important for watershed protection, wildlife habitat, and landscape values. Most of the steeply sloping ground is in good hydrologic forest cover.

A project is proposed for flood prevention on agricultural and urban areas and drainage of agricultural lands. The area included in the watershed contains 19,835 acres of land, of which 14,511 acres are cropland, 3,269 acres are forest, 1,668 acres rural non-farm and urban, and 387 acres miscellaneous uses.

Full benefits from flood prevention will best result from the coordinating of USDA's project in this watershed and Corps of Engineers flood control projects on the Nooksack River. The USDA proposes land treatment measures on watershed lands and the reconstruction, realignment, and stabilization of 19 miles of channels, the construction of five outlet structures including floodgates and pumps, and the necessary dike modification and strengthening to insure the satisfactory operation of these facilities.

Coordination in the installation of these projects will result in the enhancement of benefits from each project.

Installation cost is estimated to be $2,370,000, of which the Federal share is $1,786,690, and the local share is $583,310. Benefits from damage reduction and drainage are estimated to provide a benefit-cost ratio of 2.8 to 1. To achieve benefits made possible by the structural works and other management during a 15-year period, local interests will install necessary land treatment measures for erosion control and flood management costing approximately $1,031,738, drainage measures estimated to cost $2,523,564, and forest protection and management practices costing $68,192, for a total of $3,623,494. The total cost of installing the structural measures and the land treatment measures is $5,993,494.

**Sumas River Watershed Area 11-3, Figure 3-1** is located in the northwest part of Whatcom County. This watershed drains to the north and is tributary to the Vedder River, which in turn is tributary to the Fraser River. During high floodflows of the Nooksack some excess water will occasionally enter the Sumas

Channel and flow north to enter the Fraser River.

About 65 percent of this watershed has a forest cover. There are tracts of small hardwood stands on the flood plain. The principal forest is on the upland areas around the Sumas Mountains, which form the east boundary. The lower slopes have mostly regenerated to mixed stands of Douglas-fir and red alder on the lower slopes and to Douglas-fir and western hemlock on the upper slopes. Extra care must be exercised in the management of stands on these unstable and susceptible soils to reduce the detritus and sediment causing damage to the Sumas River channel.

A project is proposed for flood prevention on agricultural and urban areas and drainage of agricultural lands. The area included in the watershed contains 33,079 acres of land, of which 18,287 acres are cropland, 12,650 acres are forest, 1,219 acres rural non-farm and urban, and 923 acres miscellaneous uses.

The works of improvement will consist of approximately 22 miles of channel improvement and stabilization. Ten miles will be on the Sumas River and its tributaries, 3 miles on Bone Creek, and 9 miles on Johnson Creek and its tributaries. One debris basin will be installed on Swift Creek to detain and control the sediment resulting from a n active landslide on Sumas Mountain.

Installation cost is estimated to be $1,241,295, of which the Federal share is $795,615, and the local share is $445,680. Benefits from damage reduction and drainage will provide a benefit-cost ratio of 6.8 to 1. To achieve benefits made possible by the structural works and other management during a 15-year period, local interests will install necessary land treatment measures for erosion control and flood management costing approximately $1,300,208, drainage measures estimated to cost $3,195,031, and forest protection and management practices costing $263,880, for a total of $4,759,119. The total cost of installing the structural measures and the land treatment measures is $6,000,414.

**Dakota Creek Watershed Area 0-1, Figure 3-1** is the first watercourse of any size south of the Canadian boundary. It flows in a northwest direction and discharges into Drayton Harbor. About 70 percent of this watershed is forest covered. About one-third of the area has regenerated to mixed Douglas-fir and red alder stands following logging. The main objectives of the present forest owners may still be the harvest of wood products, but watershed protection, wildlife habitat, and recreation and aesthetic values are becoming more significant. Grass and wood products are the principal crops grown in the watershed.

A project is proposed for flood prevention on agricultural and urban areas and drainage of agricultural lands. The area included in this watershed contains 20,314 acres of land, of which 8,270 acres are cropland, 9,706 acres are forest, 1,491 acres rural non-farm and urban, and 847 acres miscellaneous uses.

The works of improvement, mostly in the upper reaches of the watershed, will consist of approximately 18 miles of channel improvement and stabilization.

Installation cost is estimated to be $430,480, of which the Federal share is $280,405, and the local share is $150,075. Benefits from damage reduction and drainage will provide a benefit-cost ratio of 2.9 to 1. To achieve benefits made possible by the structural works and other management during a 15-year period, local interests will install necessary land treatment measures for erosion control and flood management costing approximately $587,992, drainage measures expected to cost $472,470, and forest protection and management practices costing $202,468, for a total of $1,262,930. The total cost of installing the structural measures and the land treatment measures is $1,693,410.

**California Creek Watershed Area 0-4, Figure 3-11.** California Creek flows northwest and outlets into Drayton Harbor at Blaine. The watershed is primarily agricultural, and it has a rolling topography.

About half of the watershed is forest covered with mixed stands of young Douglas-fir, red alder, and paper birch. Black cotton wood stands are common on the bottom lands. Some tracts are managed for their wood fiber, but many woodlot owners are interested in them for wildlife habitat, recreational, and environmental qualities.

A project is proposed for flood prevention on agricultural and urban areas and drainage of agricultural lands. The watershed includes 14,192 acres, of which 8,384 acres are cropland, 4,118 acres are forest, 919 acres rural non-farm and urban, and 771 acres miscellaneous uses.

The works of improvement will consist of approximately 14 miles of channel improvement and stabilization and one reservoir for floodwater retention, recreation, and irrigation.

Installation cost is estimated to be $470,985 of

which the Federal share is $313,750, and the local share is $157,235. Benefits from damage reduction and drainage will provide a benefit-cost ratio of 3.4 to 1. To achieve benefits made possible by the structural works and other management during a 15-year period, local interests will install necessary land treatment measures for erosion control and flood management costing approximately $596,092, drainage measures expected to cost $566,545, and forest protection and management practices costing $85,901, for a total of $1,248,538. The total cost of installing the structural measures and the land treatment measures is $1,719,523.

**Silver (Marietta) Creek Watershed Area 0-5, Figure 3-1** is located about 10 miles north and west of Bellingham. Several good roads make access to the area easy and quick. About 40 percent of the area is non-farm land with a ground cover of small hardwoods. The current trend is to develop this portion for country living. Development is also fostered by being adjacent to the Pacific Highway and Bellingham airport. Planning is essential in this area to preserve the outdoor environment and keep it aesthetically attractive. Adequate parks and golf courses are some elements to consider in this objective. This plan contains an early action project to develop and protect the area.

A project is proposed for flood prevention on agricultural and urban areas and drainage of agricultural lands. The area included in this watershed contains 10,866 acres, of which 5,704 acres are cropland, 3,479 acres are forest, 1,264 acres rural non-farm and urban, and 419 acres miscellaneous uses.

The works of improvements will consist of 16 miles of channel improvement and stabilization, one outlet structure consisting of floodgates and pumps, and the necessary dike modification and strengthening to insure the satisfactory operation of these facilities.

Installation cost is estimated to be $1,173,155, of which the Federal share is $920,265, and the local share is $252,890. Benefits from damage reduction and drainage will provide a benefit-cost ratio of 2.1 to 1. To achieve benefits made possible by the structural works and other management during a 15-year period, local interests will install necessary land treatment measures for erosion control and flood management costing approximately $405,562, drainage measures expected to cost $779,279, and forest protection and management practices costing $72,572, for a total of $1,257,418. The total cost of installing the structural measures and the land treatment measures is $2,430,568.

## Projects after 1980

Projects for the years 1980-2000 and 2000-2020 are shown in Table 3-8 with their expected costs. Benefits and benefit-cost ratios have not been computed for projects past 1980. Total installation cost is expected to be $6,886,000.

**TABLE 3-8. Costs of projects recommended for installation after 1980**

| Watershed Area No.[1] and Name | Project Area (acres) | Struc. Meas. Installation Cost[2] (dollars) |
|---|---|---|
| 1980-2000 | | |
| 10-3 South Fork Nooksack | 122,178 | 600,000 |
| 10-4 Middle Tributaries Nooksack[3] | 56,095 | 1,400,000 |
| 10-5 Anderson Creek | 8,789 | 300,000 |
| 0-2 Coastal Creeks | 16,981 | 550,000 |
| 0-3 Terrell Creek | 9,503 | 1,900,000 |
| 0-6 Squalicum Creek | 17,236 | 650,000 |
| 0-9 Lummi Island | 11,744 | 550,000 |
| Total | 203,133 | 5,950,000 |
| 2000-2020 | | |
| 10-1 North Fork Nooksack | 180,977 | 286,000 |
| 10-2 Middle Fork Nooksack | 62,845 | 100,000 |
| 11-1 Upper South Chilliwack | 109,231 | 100,000 |
| 0-7 Lake Whatcom | 36,835 | 300,000 |
| 0-8 Chuckanut Mountain | 22,352 | 150,000 |
| Total | 412,240 | 936,000 |

1 See Figure 3-1 for location.

2 1967 prices.

3 Part of watershed.

## Programs

Program measures refer to on-farm and urban on-site practices which take advantage of improvements made possible by the structural works of improvement, as well as measures for watershed

protection, erosion control, and water management. These measures will include seeding of improved grasses and legumes, cover crops, cropland and urban drainage development made possible by a structural works of improvement, forest management practices, and irrigation development.

Table 3-9 shows a breakdown of the various practices for each of the three time periods:

## Summary of costs

Costs for the Nooksack-Sumas Basins plan (project costs plus program costs, rounded to the nearest thousand dollars) are expected to be $71,505,000 for the early action program; $76,339,000 for the years 1980-2000; and $66,309,000 for the years 2000 through 2020. Total cost of the plan will be $214,153,000. See page 2-89 et seq.; also page 2-95, Table 2-20, for further explanation of costs.

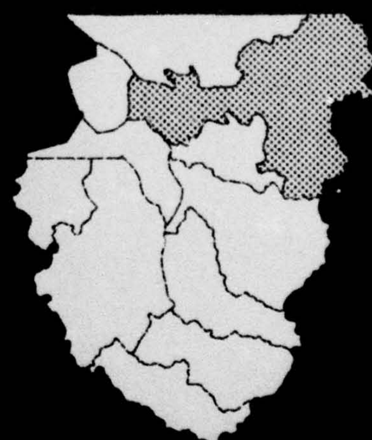
**TABLE 3-9. Watershed management practices for protection and development, by time periods, Nooksack-Sumas Basins**

| Practices | Areas (acres) | Cost[1] (thousands of dollars) | |
|---|---|---|---|
| **First 15 Years** | | | |
| Technical assistance & management | 758,673[2] | | 11,095 |
| Federal, regular | | 10,594 | |
| Federal, accelerated | | 501 | |
| Installation of practices (non-Federal) | | | 49,437 |
| State & corporate management | | 8,456 | |
| Land treatment | 472,305 | 10,961 | |
| Water management | 55,378 | 14,616 | |
| Urban drainage | 11,410 | 15,404 | |
| Total | | | 60,532 |
| **1980-2000** | | | |
| Technical assistance & management | 758,673[2] | | 12,364 |
| Federal, regular | | 11,863 | |
| Federal, accelerated | | 501 | |
| Installation of practices (non-Federal) | | | 58,025 |
| State & corporate management | | 11,276 | |
| Land treatment | 472,305 | *14,614 | |
| Water management | 36,919 | *17,864 | |
| Urban drainage | 10,571 | *14,271 | |
| Total | | | 70,389 |
| **2000-2020** | | | |
| Technical assistance & management | 758,673[2] | | 11,126 |
| Federal, regular | | 10,708 | |
| Federal, accelerated | | 418 | |
| Installation of practices (non-Federal) | | | 54,247 |
| State & corporate management | | 11,275 | |
| Land treatment | 472,305 | *14,614 | |
| Water management | 36,000 | *12,720 | |
| Urban drainage | 11,584 | *15,638 | |
| Total | | | 65,373 |

[1] Base: 1967 prices, except items asterisked which are 1967 adjusted normalized prices. See page 2-89 for further explanation of costs.

[2] Total acres in Islands involved in program measures.

# Skagit-Samish Basins



# SKAGIT-SAMISH BASINS

The Skagit-Samish Basins are located largely in Skagit County, although the eastern portion of Whatcom County and the northeastern portion of Snohomish County are within the drainage basins.

The Skagit River is the largest river in the Puget Sound Area. It drains an area of 3,105 square miles, of which nearly 400 square miles are in Canada. The principal tributaries are the Sauk River and the Baker River. The Samish River originates on a low divide south of Acme in Whatcom County and its tributary, Friday Creek, originates in the hills south of Bellingham. The drainage area of the Samish River Basin is 139 square miles. The general characteristics of the Skagit and Samish Basins are similar.

## PRESENT STATUS

The population of the Basins in 1963 was 53,800. Projections indicate that the population in 1980 will be 64,200; in 2000, 86,500; and in 2020, 118,200. Population density at the present time, based on urban and rural non-farm lands, is 1.38 people per acre.

Farming and forestry are the main users of land in the Basins. Forage production in support of a livestock industry is the largest type of farming. Many farms produce significant amounts of vegetables, berries, and vegetable seeds. In fact, the area produces an estimated 90 percent of the cabbage seed and half of the garden beet seed for the United States, plus large amounts of turnip and rutabaga seeds.

Forestry continues as a major industry of the Basins and supports several large sawmills and wood pulp plants. A large manufacturer of logging machinery is located at Sedro-Woolley. Forested lands and associated open lands comprise 1,753,445 acres.

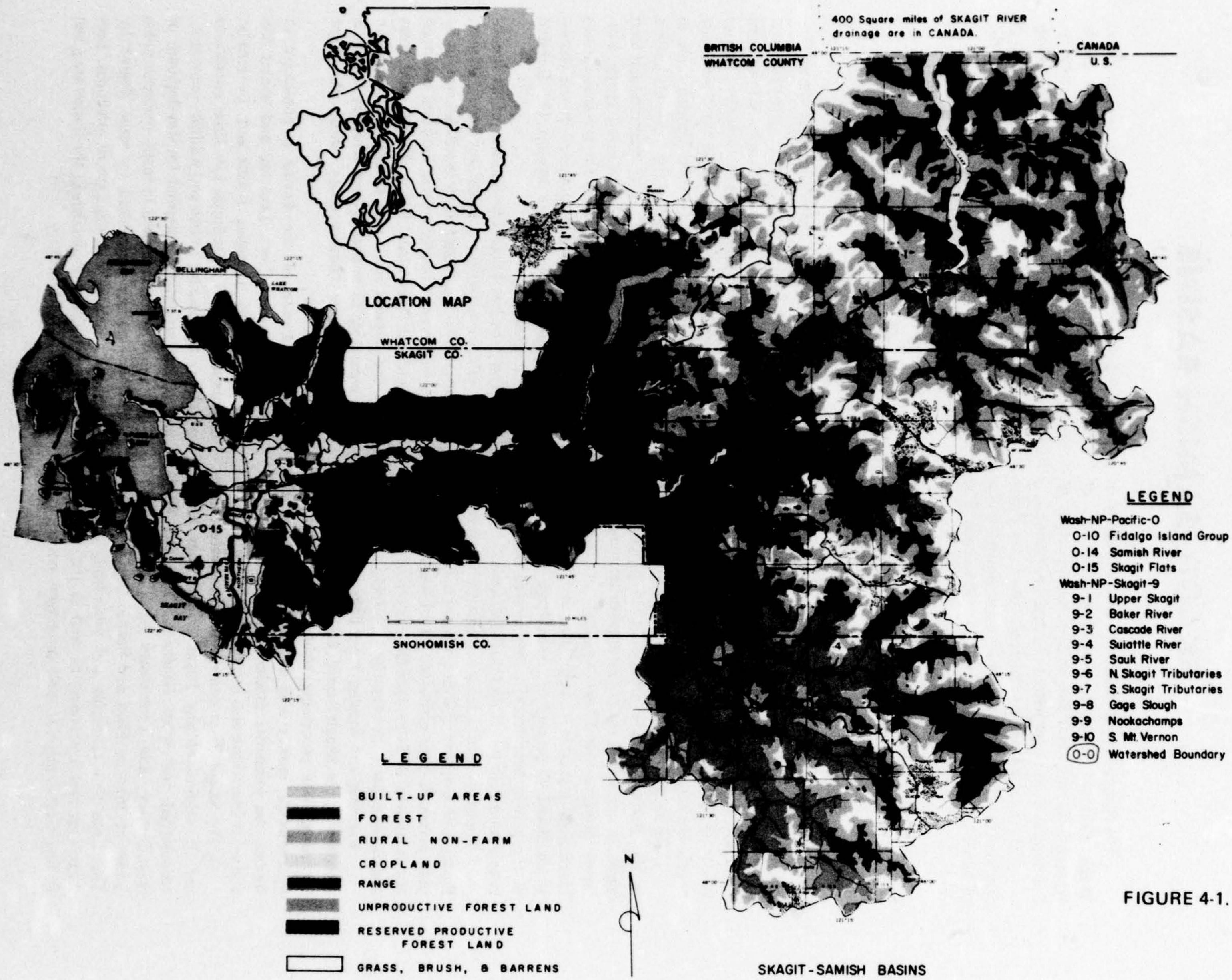
Farming and logging have been the principal activities in the Skagit-Samish Basins. Cement manufacturing, food processing, fisheries, recreation, and hydroelectric power add to the economy of the Basins. An industrial machine manufacturing plant and oil refineries are also located in the area.

The Skagit River contributes the greatest number of salmon of any Puget Sound river to the commercial and sport fisheries within the Puget Sound Area, and contributes significantly to the Strait of Juan de Fuca and Pacific Ocean fisheries. The large fish canneries and processing plants in Anacortes and LaConner, as well as the associated fishing fleets, marinas, and moorages, contribute a large part to the income and economy of the region.

The Skagit-Samish delta, including the brackish sloughs, marshes, and adjacent Skagit, Samish, and Padilla Bays, is perhaps the most important winter concentration area for waterfowl on the West Coast of the United States and Canada. Upland game in moderate amounts are found in the lowlands but are declining in numbers due to shifts in agricultural land from cereal grains to more specialized crops. Fur-bearing animals are numerous in the lower elevations due to the favorable habitat provided by the basins. Several species of big game inhabit the forested mountain areas.

The area has long been famous for its mountains, wilderness, streams, lakes, salt water, islands, and shorelands. The Skagit River is well known for its natural beauty; and tremendous salmon and steelhead runs, and the man-made Baker, Diablo, and Ross Lakes are popular recreation attractions. Deception Pass, separating these basins from Whidbey Island, is one of the major "beauty spots" within the Puget Sound Study Area.

The climate of the Basins is conducive to extremes in streamflows. Late fall and winter frequently produce damaging floods and, conversely, midsummer drought produces low flow conditions which are detrimental to fish and wildlife, recreation, and stream sanitation. Potential for development of streams and rivers is limited in many respects unless low flows can be augmented to some degree by structural measures and managment practices. Low flow characteristics of streams in the Basins are given in Appendix III, Hydrology.




SKAGIT-SAMISH BASINS
GENERALIZED LAND USE MAP

FIGURE 4-1.

The present condition, of many stream and river channels in these Basins is partly the result of exploitation by man and partly due to natural factors. Only in the last few years have efforts been made to protect and rehabilitate the environment. Streambank erosion is severe in places where sediment and debris reduce channel capacity.

Small slides have occurred on many of the tributaries to the major rivers of the basins. Debris dams from previous logging operations and beaver colonies are present on many tributaries and are a hazard when high flows occur.

## PRESENT LAND USE

The Skagit-Samish Basins provide the largest valley system in the Puget Sound Area. The lower flood plain contains about 90,000 acres of nearly level and gently undulating river bottom lands and tidelands. The system includes many flood and drainage problem areas which require corrective measures before their potential may be attained (see Figure 4-1). The ownership distribution of the Basin's lands are shown on Figure 4-2.

The broad categories of land use are given in Table 4-1. No attempt is made here to quantify multiple use management of lands, such as game habitat, recreation, water quality, or low flow augmentation. These Basins are noted for large areas of good cropland

## SOILS

A medium-intensity soil survey is available for most lands outside the national forest and national park boundaries. Lands within the national forest and national park were mapped from a reconnaissance-type survey.

The mapping units are discussed in soil survey reports for the Skagit, Whatcom and Snohomish Counties and their locations are shown on maps. The soil survey report is available in libraries and in local offices of the United States Department of Agriculture.

The principal properties of each soil series are tabulated in Exhibit 1, Table 6, of this Appendix. Interpretations of data for each soil series are provided in subsequent tables of Exhibit 1.

The total land area of 1,912,500 acres in the

**TABLE 4-1. Present land use by sub-basins**[1]

| Land Use | Skagit River Basin (acres) | Samish River Basin (acres) | Puget Sound Drainages (acres) | Total (acres) |
|---|---|---|---|---|
| Cropland | 41,015 | 27,737 | 31,713 | 100,465 |
| Rangeland | 11,445 | 4,195 | 4,108 | 19,748 |
| Forest[2] | 1,667,693 | 51,765 | 33,987 | 1,753,445 |
| Rural Non-farm | 14,386 | 2,089 | 3,617 | 20,092 |
| Urban Built-up | 9,896 | 1,896 | 7,012 | 18,804 |
| Freshwater | 31,639 | 983 | 2,787 | 35,409 |
| Total | 1,776,074 | 88,665 | 83,224 | 1,947,963 |

[1] Unadjusted measurements, 1966, for Puget Sound Area Study. Tabulations by ADP. First three figures are significant figures for acreages.

[2] Includes non-forested land normally associated with forest.

Skagit-Samish Basins has a medium-intensity survey on 523,000 acres and a low-intensity survey on 1,389,500 acres. Of the 523,000 acres, 270,000 acres are classified in Land Capability Classes II through VI, 245,000 acres are in Class VII, and 8,500 acres are in Class VIII (Figure 4-3).

Lands in Land Use Capability Classes II through VI (270,000 acres) have the greatest potential for development; i.e., changed use or improved use. Land Use Capability Classes II, III, and IV may be suited for either crop or urban uses, and Class VI lands have potential for urban development. Most of the Class II and Class III lands in these Basins are subject to flooding and have wetness conditions which present hazards for many developed uses. Class VII is expected to be limited largely to forest use, and Class VIII to recreation or aesthetic uses.

The soil types in the Area having a medium-intensity survey have been classified into land use capability classes and their primary and secondary subclasses and capability units (see Exhibit 1, Tables 9-10). Lands having only reconnaissance surveys are roughly grouped into capability classes. Tables 4-2 and 4-3 which follow give a tabulation of capability subclasses and specific wetness conditions for surveyed lands in these basins.

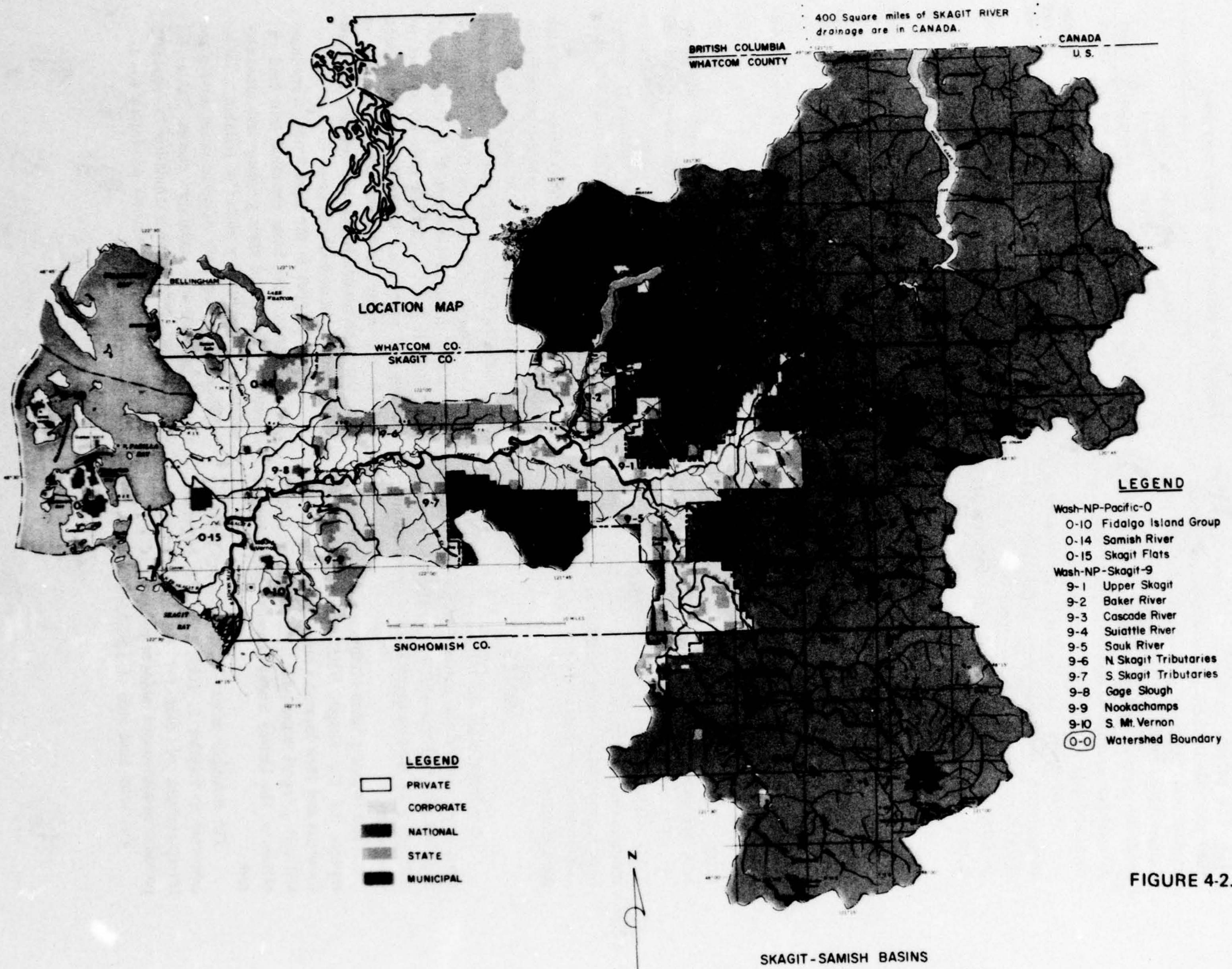
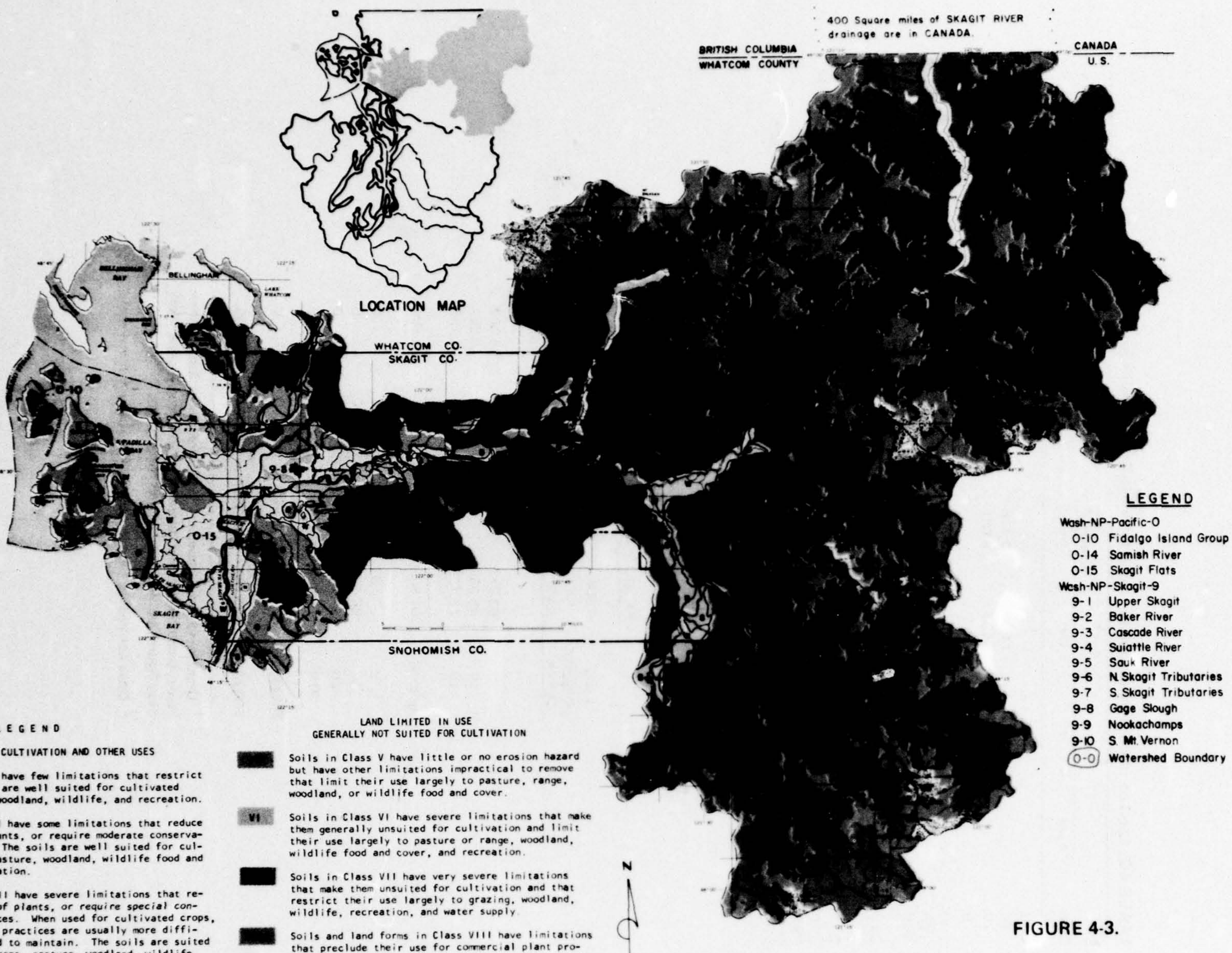



FIGURE 4-2.

SKAGIT-SAMISH BASINS
GENERALIZED OWNERSHIP MAP




LEGEND

LAND SUITED FOR CULTIVATION AND OTHER USES

Soils in Class I have few limitations that restrict their use. They are well suited for cultivated crops, pasture, woodland, wildlife, and recreation.

II — Soils in Class II have some limitations that reduce the choice of plants, or require moderate conservation practices. The soils are well suited for cultivated crops, pasture, woodland, wildlife food and cover, and recreation.

III — Soils in Class III have severe limitations that reduce the choice of plants, or require *special conservation practices*. When used for cultivated crops, the conservation practices are usually more difficult to apply and to maintain. The soils are suited for cultivated crops, pasture, woodland, wildlife food and cover, and recreation.

Soils in Class IV have very severe limitations that restrict the choice of plants, *require very careful management*, or both. The soils in Class IV may be used for crops, pasture, woodland, wildlife food and cover, and recreation.

LAND LIMITED IN USE
GENERALLY NOT SUITED FOR CULTIVATION

Soils in Class V have little or no erosion hazard but have other limitations impractical to remove that limit their use largely to pasture, range, woodland, or wildlife food and cover.

VI — Soils in Class VI have severe limitations that make them generally unsuited for cultivation and limit their use largely to pasture or range, woodland, wildlife food and cover, and recreation.

Soils in Class VII have very severe limitations that make them unsuited for cultivation and that restrict their use largely to grazing, woodland, wildlife, recreation, and water supply.

Soils and land forms in Class VIII have limitations that preclude their use for commercial plant production and restrict their use to recreation, wildlife, water supply, or esthetic purposes.

PRIMARY SUBCLASSES

e-Potential erosion or past erosion damage, sediment source.
w-Wetness, poor drainage or overflow.
s-Shallowness, stoniness or low moisture-holding capacity, etc.

FIGURE 4-3.

SKAGIT-SAMISH BASINS
GENERALIZED LAND CAPABILITY MAP
Class and Subclass

**TABLE 4-2. Land conditions by capability classes in Skagit-Samish Basins (in acres)[1]**

| Class | Subclasses [2] | | | | | | | | | Class Total |
|---|---|---|---|---|---|---|---|---|---|---|
| | e | w | s | ew | es | we | ws | se | sw | |
| II | | | 862 | | | | 82,150 | | | 83,012 |
| III | | | 8,554 | 1,600 | 2,416 | | 32,610 | | 479 | 45,659 |
| IV | | | 1,981 | 40,183 | 8,081 | | 20,384 | 265 | 2,241 | 73,135 |
| V | | | | | | | 39 | | | 39 |
| VI | | | 25,652 | 14,401 | 16,865 | | 7,094 | 4,110 | | 68,121 |
| VII | | | 1,105 | 2,751 | 240,409 | | 435 | | | 244,700 |
| VIII | | | 717 | 504 | | | 7,294 | | | 8,515 |
| TOTAL | | | 38,870 | 59,439 | 267,771 | | 150,006 | 4,375 | 2,720 | 523,181 |

[1] Unadjusted measurements, 1966, for Puget Sound Area Study, based on National Cooperative Soil Survey maps. First three figures are significant figures for acreages. Does not include land within national forests and national parks.

[2] Letters for subclasses denote hazards or conditions that affect land use and treatment: e—erosion; w—wetness; s—soil.

**TABLE 4-3. Land with wetness condition by capability classes, Skagit-Samish Basins (in acres)[1]**

| Land Capability Classes | All land in basins[2] | | Cropland in basins | |
|---|---|---|---|---|
| | Total *All* Land | With *Wetness* Condition | *Total* Cropland (est.) | Cropland With *Wetness* Condition (est.) |
| II | 83,012 | 82,150 | 78,861 | 78,042 |
| III | 45,659 | 34,689 | 14,391 | 8,852 |
| IV | 73,135 | 62,808 | 7,213 | 4,195 |
| Subtotal | 201,806 | 179,647 | 100,465 | 91,089 |
| V | 39 | 39 | 0 | 0 |
| VI | 68,121 | 21,495 | 0 | 0 |
| VII | 244,700 | 3,186 | 0 | 0 |
| VIII | 8,515 | 7,798 | 0 | 0 |
| Subtotal | 321,375 | 32,518 | 0 | 0 |
| TOTAL | 523,181 | 212,165 | 100,465 | 91,089 |

[1] Unadjusted measurements, 1966, for Puget Sound Area Study, based on National Cooperative Soil Survey maps. First three figures are significant figures for acreages.

[2] Does not include land in national forest and national park.

# PRESENT AND FUTURE NEEDS

## EVALUATION OF PRESENT SITUATION

In the Skagit-Samish Basins three broad categories of needs–protection from floodwater damage, measures for watershed protection and rehabilitation, and measures for water management–are present in varying degrees of intensity according to land use. About 100,465 acres are devoted to cropland use at the present time; 1,753,445 acres are in forest (including some areas of non-forested land); 19,748 are classed as rangeland; and 38,896 acres are in intensive uses. According to Appendix VII, Irrigation, 6,200 acres were under irrigation in 1966.

## ESTIMATED FUTURE NEEDS

Determination of needs is made on the basis of multiple-use management and the categories of floodwater damage reduction. Watershed protection and rehabilitation measures, agricultural water management, and urban drainage contain the practices needed for development under the concept. Development needed in forestry and farming is to keep pace with other needs as the population increases and reach the level required by 2020.

Future needs are given in acres of land to be treated. Intensity or degree of practice application will increase with use. Management practices for enhancement of multiple-use objectives may require several practices on the same acre of land. A partial listing of practices used is given in Tables 2-18 and 2-19 in the Puget Sound Area section of this Appendix under Means to Satisfy Needs.

The projected rapid rise in population, with its requirements for space, recreation, and other land and water needs, makes it necessary to initiate an early action program of development to avoid costly misuse of the land resource. An obvious need in these Basins is for improved floodwater damage reduction measures on the lower flood plain of the Skagit River. This need is described in Appendix XII, Flood Control. There is also immediate need for flood prevention and drainage facilities to be installed on four watersheds to accommodate orderly development of the Basins. Details of these early action, and other future project needs are found in the Means to Satisfy Needs section.

Projections are that these Basins will remain for the most part, agricultural, with some industrial development to take place in the western part of the Basins. The estimated number of acres, according to land use, that will require protection and development measures by the years 1980, 2000, and 2020 are tabulated in Table 4-4. The same land area may require practices from more than one of these categories.

**TABLE 4-4. Future needs for watershed management [1]**

| Year | Floodwater Damage[2] Reduction[3] (acres) | Watershed Protection & Rehab.[3] (acres) | Drainage Improvement[3] (acres) | Irrigation Development[3] ment[4] (acres) |
|---|---|---|---|---|
| Cropland | | | | |
| 1980 | 90,439 | 120,748[5] | 49,023 | 40,000 |
| 2000 | 90,439 | 124,748[5] | 81,705 | 60,000 |
| 2020 | 90,439 | 134,748[5] | 108,940[6] | 95,000 |
| Intensive Land Use | | | | |
| 1980 | 30,490 | 38,896 | 38,896 | 0 |
| 2000 | 30,490 | 38,896 | 38,896 | 0 |
| 2020 | 30,490 | 38,896 | 38,896 | 0 |
| Forested Land[7] | | | | |
| 1980 | 0 | 1,752,910 | 0 | 0 |
| 2000 | 0 | 1,748,910 | 0 | 0 |
| 2020 | 0 | 1,738,910 | 0 | 24,900[8] |

[1] Acreages derived by map measurements and ADP tabulation for the PS&AW study. Other potential not tabulated. Unrounded figures do not denote accuracy beyond the first thee significant figures.

[2] Includes overbank flooding of main streams.

[3] Needed for full agricultural development (see Appendix V, Water-Related Land Resources, chapter 2, Agriculture).

[4] According to Appendix VII, Irrigation, there were 6,200 acres (using 11,904 acre feet of water) irrigated in 1966. Irrigation Appendix projections show 16,200 acres irrigated by 1980, 26,200 acres by 2000, and 51,200 acres by 2020.

[5] Includes 19,748 acres of rangeland.

[6] Does not agree with Table 4-3 due to land use changes during time lapse.

[7] Includes some non-forested land commonly associated with forests.

[8] Potential irrigation of forests (see Appendix V, chapter 3, Forestry).

Table 4-5 shows drainage groups by watersheds in the Skagit-Samish Basins, with the acreage in each drainage group. From this and other data the drainage needs for expected land uses in the Basins are derived.

**TABLE 4-5. Drainage groups in Skagit-Samish Basins[1] (in acres)[2]**

| LINE | Watershed Area No.[3] | River Basins And Watersheds | 01 | 02 | 03 | 04 | 05 | 06 | 07 | 08 | 09 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Skagit River Basin | | | | | | | | | | | | | | | | | |
| 1 | 9-1 | Upper Skagit River | 5,976 | 0 | 8 | 0 | 0 | 85 | 0 | 0 | 38 | 140 | 65 | 0 | 0 | 2 | 0 | 610 | 6,924 |
| 2 | 9-2 | Baker River | 54 | 0 | 98 | 12 | 0 | 103 | 0 | 0 | 0 | 0 | 3,027 | 78 | 0 | 0 | 0 | 0 | 3,372 |
| 3 | 9-3 | Cascade River | 466 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 190 | 656 |
| 4 | 9-4 | Suiattle River | 1,220 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 5 | 0 | 55 | 0 | 190 | 1,470 |
| 5 | 9-5 | Sauk River | 5,440 | 0 | 95 | 0 | 0 | 35 | 0 | 95 | 0 | 0 | 20 | 35 | 0 | 150 | 0 | 1,078 | 6,948 |
| 6 | 9-6 | North Skagit Tribs. | 10,703 | 0 | 114 | 2 | 0 | 385 | 0 | 0 | 113 | 1,011 | 1,727 | 18 | 0 | 386 | 0 | 454 | 14,913 |
| 7 | 9-7 | South Skagit Tribs. | 5,257 | 0 | 10 | 0 | 0 | 62 | 0 | 0 | 30 | 0 | 803 | 15 | 0 | 1,435 | 0 | 1,172 | 8,784 |
| 8 | 9-8 | Gages Slough | 12,025 | 0 | 3 | 13 | 0 | 2 | 0 | 0 | 0 | 1,408 | 425 | 18 | 0 | 7 | 0 | 104 | 14,005 |
| 9 | 9-9 | Nookachamps | 5,693 | 0 | 425 | 60 | 0 | 106 | 0 | 0 | 1,130 | 4,411 | 11,477 | 177 | 0 | 66 | 0 | 68 | 23,612 |
| 10 | 9-10 | South Mt. Vernon | 9,423 | 0 | 778 | 60 | 0 | 827 | 0 | 55 | 633 | 2,883 | 7,051 | 91 | 0 | 10 | 0 | 386 | 22,197 |
| 11 | | Total | 56,257 | 0 | 1,531 | 147 | 0 | 1,604 | 0 | 150 | 1,944 | 9,853 | 24,595 | 437 | 0 | 2,111 | 0 | 4,252 | 102,881 |
| | | Samish River Basin | | | | | | | | | | | | | | | | | |
| 12 | 0-14 | Samish River | 22,444 | 0 | 970 | 969 | 0 | 778 | 0 | 0 | 1,407 | 10,698 | 8,208 | 1,132 | 0 | 817 | 0 | 498 | 47,921 |
| 13 | | Total | 22,444 | 0 | 970 | 969 | 0 | 778 | 0 | 0 | 1,407 | 10,698 | 8,208 | 1,132 | 0 | 817 | 0 | 498 | 47,921 |
| | | Puget Sound Drainages | | | | | | | | | | | | | | | | | |
| 14 | 0-10 | Fidalgo Island | 2,915 | 0 | 131 | 0 | 0 | 519 | 0 | 0 | 878 | 5,821 | 10,218 | 268 | 0 | 170 | 0 | 450 | 21,370 |
| 15 | 0-15 | Skagit Flats | 29,818 | 0 | 0 | 0 | 0 | 737 | 0 | 0 | 400 | 6,120 | 163 | 65 | 0 | 0 | 0 | 2,647 | 39,950 |
| | | Total | 32,733 | 0 | 131 | 0 | 0 | 1,256 | 0 | 0 | 1,278 | 11,941 | 10,381 | 333 | 0 | 170 | 0 | 3,097 | 61,320 |
| | | Grand Total | 111,434 | 0 | 2,632 | 1,116 | 0. | 3,638 | 0 | 150 | 4,629 | 32,492 | 43,184 | 1,902 | 0 | 3,098 | 0 | 7,847 | 212,122 |

[1] Descriptions of drainage groups are found in the Means to Satisfy Needs section of the Area report.

[2] Unadjusted measurements, 1966, for Puget Sound Area Study. Tabulations by ADP. Read three significant figures.

[3] See Figure 4-1 for location.

# MEANS TO SATISFY NEEDS

Projections indicate that by the year 2020 population in the Skagit-Samish Basins will be 118,200. The means to be used to achieve the levels necessary to meet the needs of this expected population consist of programs and projects for protection and development of the land and water resources of the Basins. The wise use and development of these resources can supply the spatial needs and aesthetic wants of the growing population in these Basins. The needs as developed in other appendices have been considered in this appendix as related to the land and water resources of the basins.

The objective of the plan for watershed management are to develop the Basin's resources to achieve their potential production of food and fiber as economically justified; to preserve and enhance fish, wildlife, and recreation values in accord with the Fish and Wildlife, and Recreation Appendices: to provide for development of urban areas not subject to floodwater hazard, and to provide spatial needs in keeping with aesthetic qualities of the area. These objectives will be carried out by various agencies of the Federal and State governments working in close cooperation with each other and with private sources.

## Land Use

Table 4-1 in Present Status indicates by sub-basins the present land use. Table 4-6 summarizes by time periods the estimated future use of the land.

## Flooding

Floodwater damage must be prevented to the extent the hazard remaining does not materially exceed other risks before development is practical. Loss is limited to tolerable levels by restricting intensive uses of land in hazardous areas. Watersheds

TABLE 4-6. Estimated future land use

| Year | Crop-land (acres) | Range-land (acres) | Forest[1] (acres) | Urban Built-up[2] (acres) | Fresh water (acres) | Total (acres) |
|---|---|---|---|---|---|---|
| 1980 | 101,000 | 19,748 | 1,752,910 | 38,896 | 35,409 | 1,947,963 |
| 2000 | 105,000 | 19,748 | 1,748,910 | 38,896 | 35,409 | 1,947,963 |
| 2020 | 115,000 | 19,748 | 1,738,910 | 38,896 | 35,409 | 1,947,963 |

1 Includes non-forested land normally associated with forest.

2 Rural non-farm is assumed to be all urban by 1980. Built-up is based on average urban density of six persons per acre.

require varied combinations and intensities of management according to land capability and use. Programs are planned to stabilize land and related water and thus benefit most functional uses of water. Special objectives for improvement may be selected for project purposes.

## PLAN OF DEVELOPMENT

This plan to provide for the satisfaction of needs, as brought out in the Needs discussion, will utilize the program and project approach as explained in the Puget Sound Area section. The plan will guide the development of the resources of the Skagit-Samish Basins to provide for spatial and production requirements for the expected population of its service area to the year 2020. Projects to curb excessive flood damage that occurs on the Skagit, Sauk, White–Chuck, and Samish Rivers, on Grandy Creek, and in a few of the smaller drainages should be undertaken in order to protect and enhance fish, wildlife, and recreational areas.

### Early Action Projects

Several projects will be initiated prior to 1980 to remedy existing floodwater and drainage problems and to develop lands toward their potential for continued use. Following are descriptions of projects in the early action plan as listed in Table 4-7.

**Gages Slough Watershed Area 9-8, Figure 4-1** is that area tributary to the north side of the Skagit River and includes the cities of Burlington and Sedro-Woolley, both of which lie within the flood plain. The major portion of the watershed is the flood plain of the Skagit River with only a small area of hill land which is located north of Sedro-Woolley. Gages Slough appears to have been an old watercourse of the Skagit which was abandoned and a new present channel formed about one mile to the south. The forest area is largely confined to a small area on hills

TABLE 4-7. Costs and benefited areas, early action projects recommended for installation by 1980

| Watershed Area No. and Name[1] | Project Area (acres) | Project Structural Measures Cost[2] (dollars) | Flood-water Protection (acres) | Drainage Improvement (acres) |
|---|---|---|---|---|
| 9-8 Gages Slough | 14,419 | 1,107,000 | 9,520 | 7,087 |
| 9-10 South Mt. Vernon | 32,132 | 1,434,000 | 9,619 | 10,501 |
| 0-14 Samish River[3] | 63,716 | 4,862,000 | 23,859 | 24,028 |
| 0-15 Skagit Flats | 41,148 | 3,234,000 | 31,788 | 28,402 |
| Total | 151,415 | 10,637,000 | 74,786 | 70,018 |

1 See Figure 4-1 for location.

2 1967 prices.

3 Part of watershed.

and Hart Island Slough. Woodlands on the high portions consist of mixed stands of Douglas-fir and red alder, in the lower lands, red alder and cottonwood. The upland areas provide excellent homesites and the development should be planned to enhance the landscape and preserve water resource values.

The project is feasible for flood prevention on agricultural and urban areas, and drainage of agricultural lands. The area includes 14,419 acres of which 7,100 acres are cropland, 1,362 acres are forest, 4,841 acres rural non-farm and 1,116 miscellaneous uses.

The works of improvement will consist of approximately 17 miles of channel improvement and stabilization and one outlet structure which will contain floodgates and pumps.

Installation cost is estimated to be $1,107,110, of which the Federal share is $705,140, and the local share is $401,970. Benefits from damage reduction and drainage will provide a benefit-cost ratio of 4.0 to 1. To achieve benefits made possible by the structural works and other management during a 15-year period, local interests will install necessary land treatment measures for erosion control and flood management costing approximately $549,540, drainage measures expected to cost $1,630,070 and forest protection and management practices costing $29,079, for a total of $2,208,689. The total cost of installing the structural measures and the land treatment measures is $3,315,799.

**South Mt. Vernon Watershed Area 9-10, Figure 4-1** is an area of about 50 square miles on the south and east sides of and tributary to the Skagit River. It includes the city of Mt. Vernon and most of the flood plain south of the city. About 30 square miles of hill land east of this flood plain are included in the watershed. A contour flood channel located at the base of these hills conveys floodwater from the uplands to an outlet into the south fork of the Skagit River. This channel makes possible the farming of the low-lying flood plain area. The area is cultivated annually and produces high value seed and vegetables crops. Low lands should remain in largely agricultural use.

About 60 percent of the watershed is forest covered. Forests occur mainly on the upland where there is nearly a solid stand of Douglas-fir. Following logging, many cutovers reverted to mixed Douglas-fir and red alder stands. On the higher slopes, the Douglas-fir predominates in thrifty young stands which rapidly reach log size. Much area is held for commercial timber but due to easy access and some attractive lakes, there is a great demand to acquire tracts for forest retreats. There are areas of steep ground where timber harvest, roads, or other development needs land treatment or special planning.

The project is feasible for flood prevention of agricultural and urban areas, and drainage of agricultural lands. The area contains 32,132 acres of which 11,500 acres are cropland, 14,881 acres are forest, 4,231 acres rural non-farm and urban, and 1,520 acres miscellaneous uses.

The works of improvement will consist of 22 miles of improved and stabilized channel and four outlet structures which may contain floodgates and pumps. Approximately one-half mile of protective embankment would be installed at the south side of the flood plain area.

Installation cost is estimated to be $1,433,715, of which the Federal share is $1,027,465, and the local share is $406,250. Benefits from damage reduction and drainage will provide a benefit-cost ratio of 4.1 to 1. To achieve benefits made possible by the structural works and other management during a 15-year period, local interests will install necessary land treatment measures, for erosion control and flood management costing approximately $890,100; drainage measures expected to cost $2,207,082; and forest protection and management practices costing $317,710; for a total of $3,414,892. The total cost of installing the structural measures and the land treatment measures is $4,848,607.

**The Samish River Watershed Area 0-14, Figure 4-1** outlets into Samish Bay and Leary Slough, a subwatershed outlet to Padilla Bay through the north edge of the Skagit River flood plain. The origin of the Samish is on the flood plain of the south fork of the Nooksack River. This stream has a very narrow flood plain and flows for much of its length between steep and rugged mountains. Its tributary streams, except for Friday Creek, are short and steep.

Almost all of the area outside of the flood plain is forest land, and this involves about 85 percent of the watershed. On the lower slopes there is a mixed stand of Douglas-fir and red alder, and above this is a belt of Douglas-fir. At the higher elevations, on the east side, western hemlock is the predominating species and on the crest of the ridges the forest stand consists of true firs. All the area has productive timberland that has been logged at various periods. Much of the area will continue to be managed for

harvesting of wood products, depending on size and type of ownership, accessibility and distance from more developed areas.

The project is feasible for flood prevention of agricultural and urban areas, and drainage of agricultural lands. The area contains 63,716 acres, of which 26,287 acres are cropland, 31,454 acres are forest, 2,852 acres rural non-farm and urban, and 3,123 acres miscellaneous uses.

The works of improvement will consist of 65 miles of improved and stabilized channel and five outlet structures consisting of floodgates and pumps.

Installation cost is estimated to be $4,861,780, of which the Federal share is $3,431,845, and the local share is $1,429,935. Benefits from damage reduction and drainage will provide a benefit-cost ratio of 2.8 to 1. To achieve benefits made possible by the structural works and other management during a 15-year period, local interests will install necessary land treatment measures for erosion control and flood management costing approximately $2,034,608; drainage measures expected to cost $5,421,678; and forest protection and management practices costing $671,542, for a total of $8,127,828. The total cost of installing the structural measures and the land treatment measures is $12,989,608.

**Skagit Flats Watershed Area 0-15, Figure 4-1,** is the delta of the Skagit River, lying on the north and west sides of the river and includes Fir Island. It is on nearly level land except for a few points and ridges that appear almost as islands in the level plain. The nearly level areas are mostly farmed in annual crops. This is the largest area of excellent high-producing agricultural soil in the Puget Sound Area. Almost all of the agricultural area is below 10 feet mean sea level elevation. Flood control and drainage problems are severe and many flood control and diking districts are located in the watershed.

The project is feasible for flood prevention of agricultural and urban areas, and drainage of agricultural lands. The watershed contains 41,148 acres, of which 28,487 acres are cropland, 4,834 acres are forest, 3,828 acres rural non-farm and urban, and 3,999 acres miscellaneous uses.

The works of improvement will consist of 43 miles of improved and stabilized channel, five outlet structures consisting of floodgates and pumps, and five miles of new and reconstructed dike.

Installation cost is estimated to be $3,234,435, of which the Federal share is $2,060,395, and the local share is $1,174,040. Benefits from damage reduction and drainage will provide a benefit-cost ratio of 5.1 to 1. To achieve benefits made possible by the structural works and other management during a 15-year period, local interests will install necessary land treatment measures for erosion control and flood management costing approximately $2,204,888, drainage measures expected to cost $6,453,955, and forest protection and management practices costing $103,206 for a total of $8,762,049. The total cost of installing the structural measures and land treatment measures is $11,996,484.

## Projects after 1980

Projects for the years 1980-2000, and 2000-2020 are shown in Table 4-8 with their expected costs. Benefits and benefit-cost ratios have not been computed. Total installation costs are expected to be $3,310,000.

**TABLE 4-8. Costs of projects recommended for installation after 1980**

| Watershed Area No. and Name[1] | Project Area (acres) | Struc. Meas. Installation Cost[2] (dollars) |
|---|---|---|
| 1980-2000 | | |
| 9-6 North Skagit Tributaries | 67,186 | 1,200,000 |
| 9-7 South Skagit Tributaries | 115,039 | 350,000 |
| 0-10 Fidalgo Island Group | 39,289 | 300,000 |
| Total | 221,514 | 1,850,000 |
| 2000-2020 | | |
| 9-1 Upper Skagit River | 702,355 | 760,000 |
| 9-2 Baker River | 182,231 | 100,000 |
| 9-3 Cascade River | 117,475 | 100,000 |
| 9-4 Suiattle River | 221,575 | 100,000 |
| 9-5 Sauk River | 244,446 | 400,000 |
| Total | 1,468,082 | 1,460,000 |

[1] See Figure 4-1 for location.

[2] 1967 prices.

## Programs

Program measures refer to on-farm and urban on-site practices which take advantage of improvements made possible by the structural works of

improvement, as well as measures for watershed protection, erosion control, and water management. These measures will include seeding of improved grasses and legumes, cover crops, cropland and urban drainage development made possible by structural works of improvement, for management practices, and irrigation development.

Table 4-9 shows a breakdown of the various practices for each of the three time periods.

## Summary of Costs

Costs for the Skagit-Samish Basins plan (project costs plus program costs, rounded to the nearest thousand dollars) are expected to be $98,193,000 for the early action programs; $101,076,000 for the years 1980-2000; and $110,778,000 for the years 2000 through 2020. Total cost of the plan will be $310,047,000; see page 2-89 et seq.; also page 2-95, Table 2-20, for further information on costs.

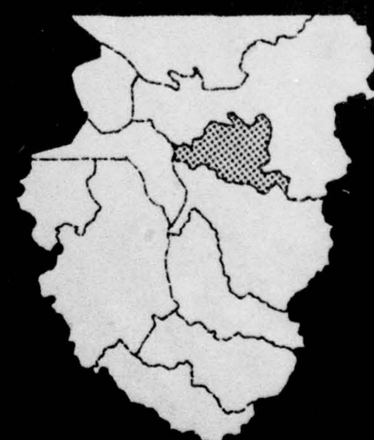
**TABLE 4-9. Watershed management practices for protection and development, by time periods, Skagit-Samish Basins**

| Practice | Area (acres) | Costs[1] (thousands of dollars) | |
|---|---|---|---|
| **First 15 Years** | | | |
| Technical assistance & management | 1,873,658[2] | | 31,995 |
| Federal, regular | | 31,750 | |
| Federal, accelerated | | 245 | |
| Installation of practices (non-Federal) | | | 55,561 |
| State & corporate management | | 9,585 | |
| Land treatment | 470,401 | 9,118 | |
| Water management | 33,600 | 14,063 | |
| Urban drainage | 16,885 | 22,795 | |
| Total | | | 87,556 |
| **1980-2000** | | | |
| Technical assistance & management | 1,873,658[2] | | 42,392 |
| Federal, regular | | 42,147 | |
| Federal, accelerated | | 245 | |
| Installation of practices (non-Federal) | | | 56,834 |
| State & corporate management | | 12,779 | |
| Land treatment | 470,401 | *12,157 | |
| Water management | 27,236 | *17,606 | |
| Urban drainage | 10,587 | *14,292 | |
| Total | | | 99,226 |
| **2000-2020** | | | |
| Technical assistance & management | 1,873,658[2] | | 37,005 |
| Federal, regular | | 36,596 | |
| Federal, accelerated | | 409 | |
| Installation of practices (non-Federal) | | | 72,313 |
| State & corporate management | | 12,779 | |
| Land treatment | 470,401 | *12,157 | |
| Water management | 49,023 | *31,955 | |
| Urban drainage | 11,424 | *15,422 | |
| Total | | | 109,318 |

[1] Base: 1967 prices, except items asterisked which are 1967 adjusted normalized prices. See page 2-89 for further explanation of costs.

[2] Total acres in Basins involved in program measures.

# Stillaguamish Basin



# STILLAGUAMISH BASIN

The Stillaguamish Basin is confined to southwestern Skagit County and northwestern Snohomish County. Approximately one-third of the Basin lies in Skagit County, and the remainder in Snohomish County.

The Stillaguamish Basin provides one of the smaller valley systems in the Puget Sound Area and drains an area of 685 square miles. Its principal tributaries are the North Fork Stillaguamish River and the South Fork Stillaguamish River.

## PRESENT STATUS

In 1963 the population was 17,600, and projections indicate that by 1980 the population will be 30,200; by 2000, 48,500; and by the year 2020 will reach 77,800. Present density per acre, based on urban and rural non-farm lands, is 1.39 people per acre.

Farming and forestry are the main users of land in the Basin. Although considerable quantities of vegetables and berries are produced, approximately three-fourths of the cropland is used to support the livestock industry. Total value of farm production is over $6 million annually.

Forestry continues as a major industry of the Basin, and supports numerous mills, including several lumber mills, a plywood mill and a cedar shake mill, and a plant which manufactures hardwood paper roll forms. Forested lands, including open areas associated with forests, comprise approximately 385,000 acres.

Farming and logging have been the principal activities in the Stillaguamish Basin. Other industry, concentrated mainly around Arlington and Silvana, includes aircraft repair, the rolling and shaping of corrugated metal pipe, a furniture plant, several freezer plants, and food processing and storage plants. Several mills, dealing with a variety of wood by-products, are also located in this area. Recreation, with fishing and dude ranching being the most prominent, plays an important part in the Basin.

The production of salmon from the Stillaguamish River contributes significantly to the commercial and sport fisheries in Puget Sound, Strait of Juan de Fuca and the Pacific Ocean.

The Stillaguamish is one of the smallest Basins, but runs high in production of forest game species and, due to an abundance of natural water areas, produces significant numbers of fur-bearing animals and waterfowl. The relatively low elevation contributes significantly to the Basin's wildlife value, as most species are limited in the areas they can inhabit by the depth and duration of winter snow.

Water-based recreation opportunities are few by comparison with other Puget Sound Basins. Frontage on Puget Sound itself is restricted to tideflat areas in the upper reaches of Port Susan and Skagit Bay. While small lakes are numerous in the mountain areas the only large lake is Lake Cavanaugh. Most water-based recreation is concentrated along the streams and rivers.

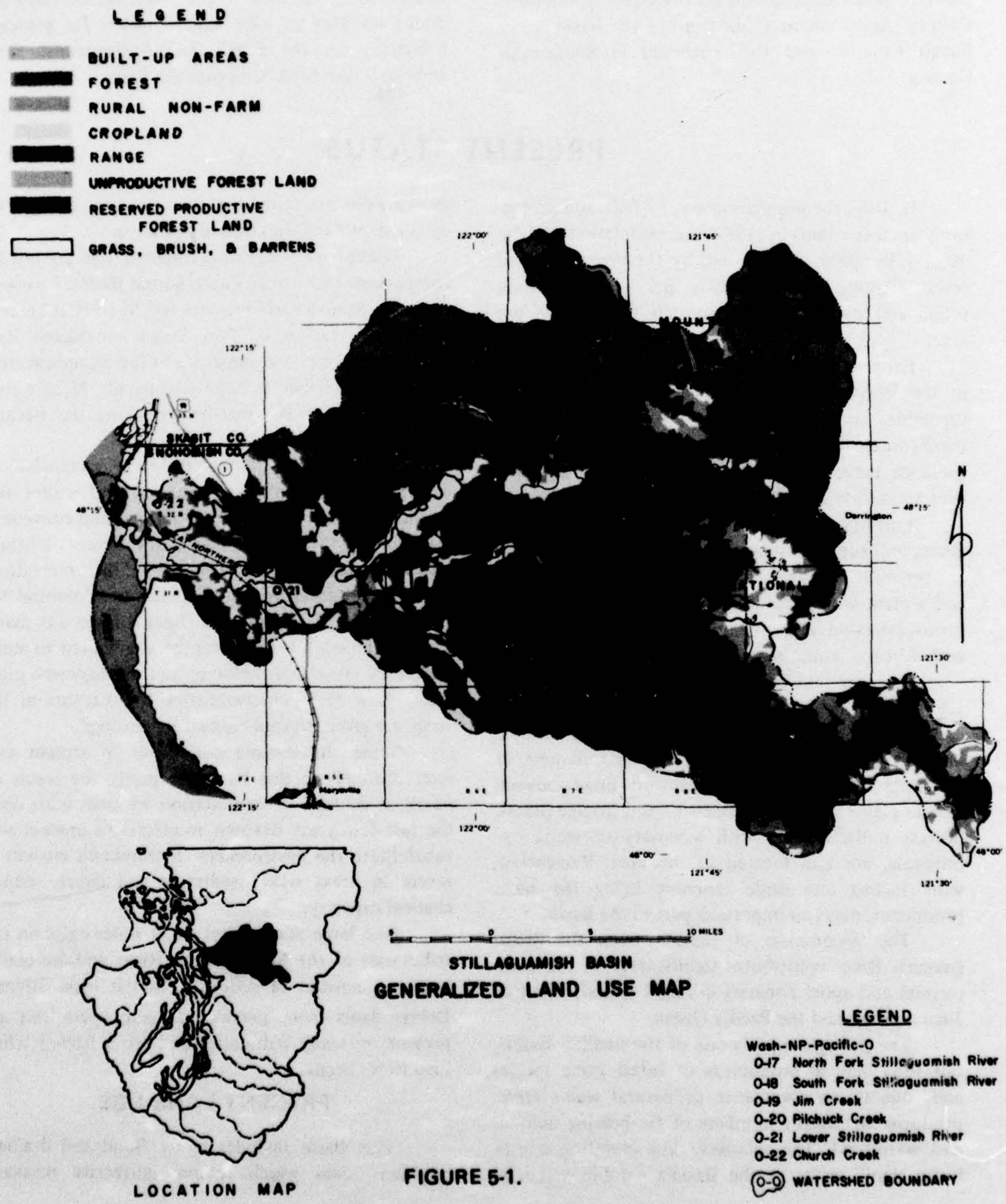
The climate of the Basin is conducive to extremes of streamflows. Late fall and winter frequently produce damaging floodflows and conversely midsummer drought produces low flow conditions which are detrimental to fish and wildlife, recreation, and to sanitation within the streams. Potential for development of streams and rivers is limited in many respects unless low flows can be augmented to some degree by structural measures and management practices. Low flow characteristics for streams in the basin are given in Appendix III, Hydrology.

Some unfavorable conditions of stream and river channels in this Basin are partly the result of nearly a century of exploitation by man with only the last few years devoted to efforts to protect and rehabilitate the environment. Streambank erosion is severe in areas where sediment and debris reduce channel capacity.

One large and several small slides exist on the tributaries of the Stillaguamish River and are contributing quantities of sediment to the main stream. Debris dams from previous logging operations are present on many tributaries and are a hazard when high flows occur.

### PRESENT LAND USE

This Basin includes many flood and drainage problem areas which require corrective measures




STILLAGUAMISH BASIN
GENERALIZED LAND USE MAP

FIGURE 5-1.

before their potential can be attained. The lower flood plain contains about 26,000 acres of level or gently undulating river bottom lands and tidelands. The upper reaches of the basin are steep, mountainous valleys, with turbulent streams. Below Arlington, the valley drops almost to sea level and widens to a flat, fertile plain as much as two miles wide and thirteen miles long (see Figure 5-1). The ownership distribution of the Basin's lands are shown on Figure 5-2.

The broad categories of land use are given in Table 5-1 which follows. No attempt is made here to quantify multiple-use mangement of lands such as for game habitat, recreation, water quality, or low flow augmentation.

**TABLE 5-1. Present land use by sub-basin [1]**

| Land Use | Stillaguamish Basin (acres) | Total (acres) |
|---|---|---|
| Cropland | 34,531 | 34,531 |
| Rangeland | 1,016 | 1,016 |
| Forest[2] | 385,450 | 385,450 |
| Rural | | |
| Non-farm | 5,932 | 5,932 |
| Urban | | |
| Built-up | 6,698 | 6,698 |
| Fresh Water | 4,721 | 4,721 |
| Total | 438,348 | 438,348 |

[1] Unadjusted measurements 1966 for Puget Sound Study. Tabulations by ADP. First three figures are significant figures for acreages.

[2] Includes non-forested land normally associated with forest.

## SOILS

A medium intensity soil survey is available for most lands outside the national forest boundaries. Lands within the national forests were mapped from a reconnaissance-type survey.

The mapping units are discussed in the soil survey reports for Skagit and Snohomish Counties and their locations are shown on maps. The soil survey report is available in libraries and in local offices of the United States Department of Agriculture.

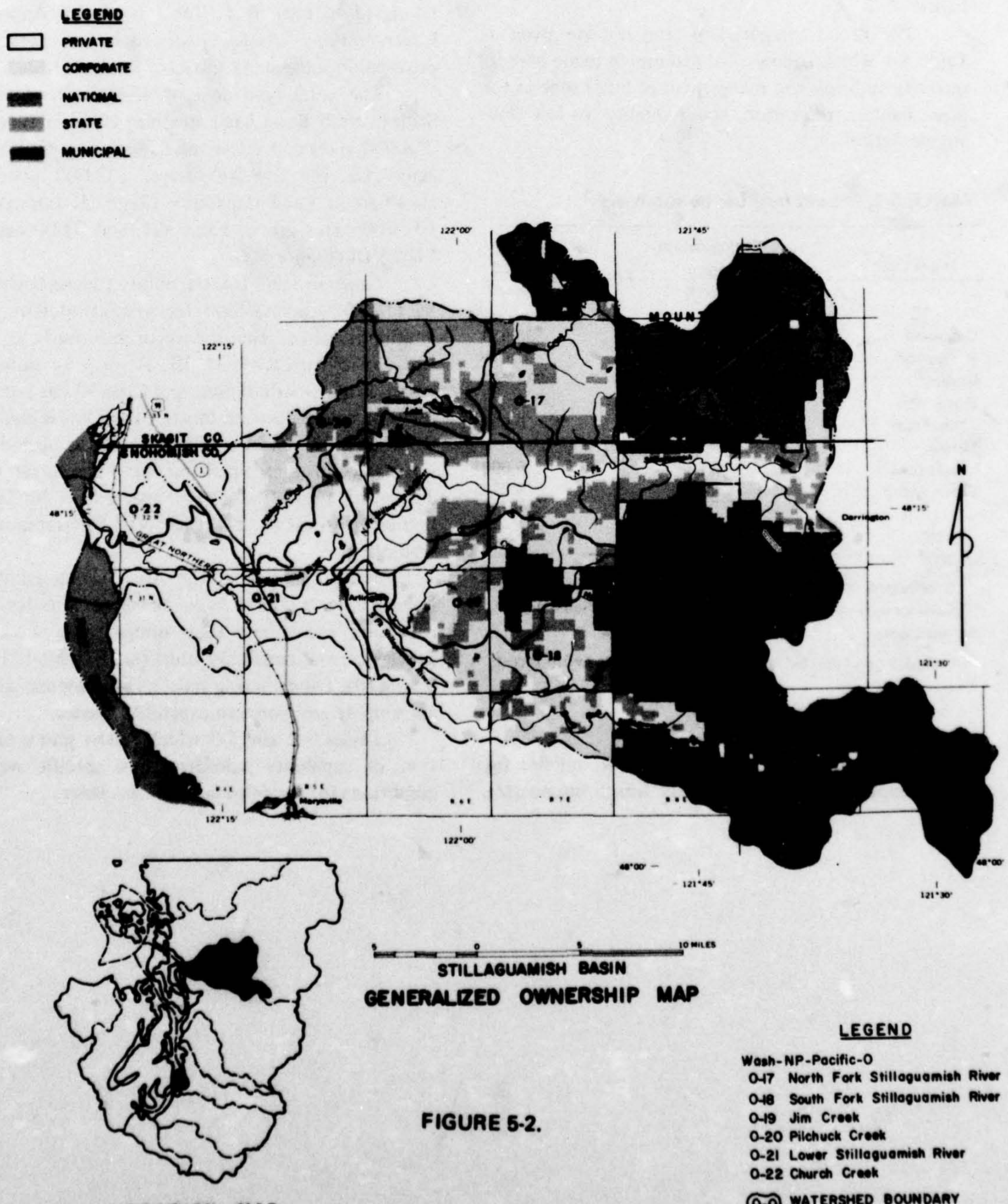
The principal properties of each soil series are tabulated in Exhibit 1, Table 6 of this Appendix. Interpretations of data for each soil series are provided in subsequent tables of the Exhibit.

The total land area of 434,000 acres in the Stillaguamish Basin has a medium intensity survey of 258,000 acres and a low intensity survey on 176,000 acres. Of the 258,000 acres, 125,000 acres are classified in Land Capability Classes II through VI, 131,000 acres are in Class VII, and 3,000 acres in Class VIII (Figure 5-3).

Lands in Land Use Capability Classes II through VI (125,000 acres) have the greatest potential for development; i.e., changed use or improved use. Land Use Capability Classes II, III, IV may be suited for either crops or urban uses, and Class VI has potential for urban development. Most of the Class II and Class III lands in the Basin are subject to flooding and have wetness conditions which present hazards for many developed uses. Class VII expected to be largely limited to forest use and Class VIII for recreation or aesthetic use.

The soil types in the Area having a medium intensity survey have been classified into land use capability classes and their primary and secondary subclasses, and capability units (see Exhibit 1, Tables 9 and 10). Lands having only reconnaissance surveys are roughly grouped into capability classes.

Tables 5-2 and 5-3 which follow give a tabulation of capability subclasses and specific wetness conditions for surveyed lands in this Basin.




STILLAGUAMISH BASIN
GENERALIZED OWNERSHIP MAP

FIGURE 5-2.

LEGEND

**LAND SUITED FOR CULTIVATION AND OTHER USES**

I — Soils in Class I have few limitations that restrict their use. They are well suited for cultivated crops, pasture, woodland, wildlife, and recreation.

II — Soils in Class II have some limitations that reduce the choice of plants, or require moderate conservation practices. The soils are well suited for cultivated crops, pasture, woodland, wildlife food and cover, and recreation.

III — Soils in Class III have severe *limitations that* reduce the choice of plants, or require special conservation practices. When used for cultivated crops, the conservation practices are usually more difficult to apply and to maintain. The soils are suited for cultivated crops, pasture, woodland, wildlife food and cover, and recreation.

IV — Soils in Class IV have very severe limitations that restrict the choice of plants, require very careful management, or both. The soils in Class IV may be used for crops, pasture, woodland, wildlife food and cover, and recreation.

**LAND LIMITED IN USE**
**GENERALLY NOT SUITED FOR CULTIVATION**

V — Soils in Class V have little or no erosion hazard but have other limitations impractical to remove that limit their use largely to pasture, range, woodland, or wildlife food and cover.

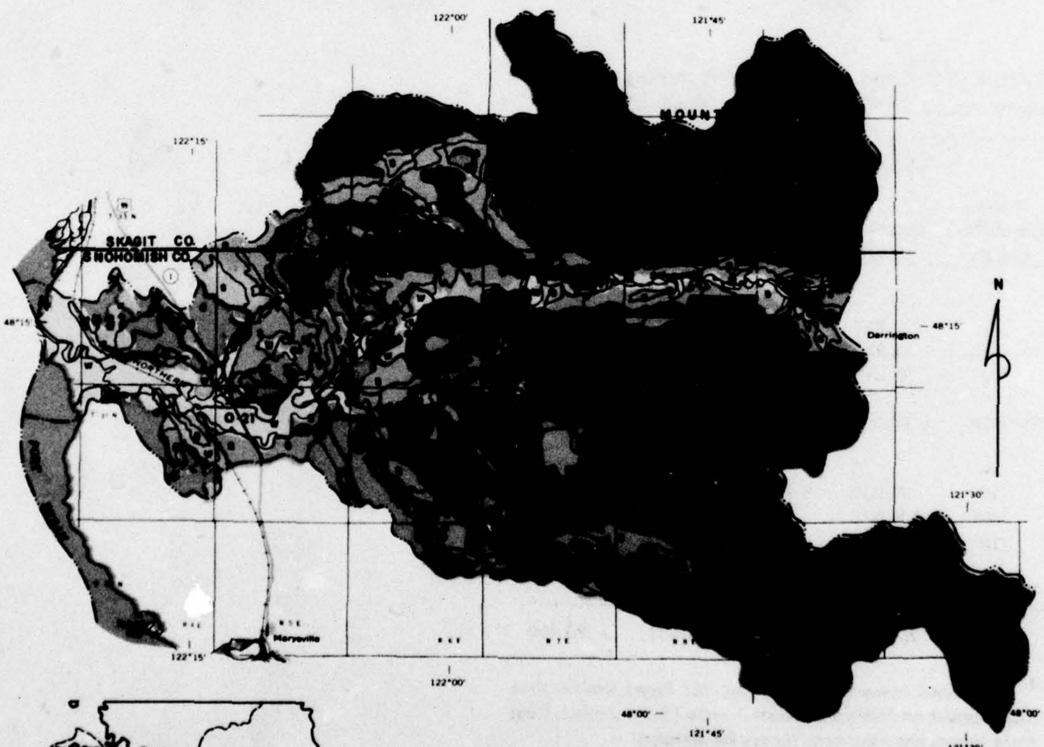
VI — Soils in Class VI have severe limitations that make them generally unsuited for cultivation and limit their use largely to pasture or range, woodland, wildlife food and cover, and recreation.

VII — Soils in Class VII have very severe limitations that make them unsuited for cultivation and that restrict their use largely to grazing, woodland, wildlife, recreation, and water supply.

VIII — Soils and land forms in Class VIII have limitations that preclude their use for commercial plant production and restrict their use to recreation, wildlife, water supply, or esthetic purposes.

**PRIMARY SUBCLASSES**

e-Potential erosion or past erosion damage, sediment source.
w-Wetness, poor drainage or overflow.
s-Shallowness, stoniness or low moisture-holding capacity, etc.




5 0 5 10 MILES

LOCATION MAP

**STILLAGUAMISH BASIN**

**GENERALIZED LAND CAPABILITY MAP**

**Class and Subclass**

**FIGURE 5-3.**

**LEGEND**

Wash-NP-Pacific-O
- O-17 North Fork Stillaguamish River
- O-18 South Fork Stillaguamish River
- O-19 Jim Creek
- O-20 Pilchuck Creek
- O-21 Lower Stillaguamish River
- O-22 Church Creek

(O-O) WATERSHED BOUNDARY

TABLE 5-2. Land conditions by capability classes in Stillaguamish Basin (in acres) [1]

| Class | Subclasses[2] | | | | | | | | | Class Total |
|---|---|---|---|---|---|---|---|---|---|---|
| | ew | s | ew | es | es | we | ws | se | sw | |
| II | | | | | | | 20,327 | | | 20,327 |
| III | | | 5,759 | 4,691 | 2,640 | | 9,529 | | 200 | 22,819 |
| IV | | | 5,556 | 21,837 | 300 | | 2,594 | 125 | | 30,412 |
| V | | | | | | | | | | 0 |
| VI | | | 24,680 | 15,541 | 6,303 | | 315 | 4,391 | | 51,230 |
| VII | | | 3,406 | 1,175 | 126,297 | | | | | 130,878 |
| VIII | | | 10 | | | | 2,649 | | | 2,659 |
| Total | | | 39,411 | 43,244 | 135,540 | | 35,414 | 4,516 | 200 | 258,325 |

[1] Unadjusted measurements, 1966, for Puget Sound Area Study, based on National Cooperative Soil Survey maps. First three figures are significant figures for acreages. Does not include land within national forests.

[2] Letters for subclasses denote hazards or conditions that affect land use and treatment; e—erosion; w—wetness; s—soil.

TABLE 5-3. Land with wetness condition by capability classes, Stillaguamish Basin (in acres) [1]

| Land Capability Classes | All land in basin[2] | | Cropland in basin | |
|---|---|---|---|---|
| | Total All Land | With Wetness Condition | Total Cropland (est.) | Cropland With Wetness Condition (est.) |
| II | 20,327 | 20,327 | 19,311 | 19,311 |
| III | 22,819 | 14,420 | 10,783 | 6,814 |
| IV | 30,412 | 24,431 | 4,437 | 3,014 |
| Subtotal | 73,558 | 59,178 | 34,531 | 29,139 |
| V | 0 | 0 | 0 | 0 |
| VI | 51,230 | 15,856 | 0 | 0 |
| VII | 130,878 | 1,175 | 0 | 0 |
| VIII | 2,659 | 2,649 | 0 | 0 |
| Subtotal | 184,767 | 19,680 | 0 | 0 |
| TOTAL | 258,325 | 78,858 | 34,531 | 29,139 |

[1] Unadjusted measurements, 1966, for Puget Sound Area Study based on National Cooperative Soil Survey maps. First three figures are significant figures for acreages.

[2] Does not include land in national forests.

# PRESENT AND FUTURE NEEDS

## EVALUATION OF PRESENT SITUTATION

In the Stillaguamish Basin three broad categories of needs–protection from floodwater damage, measures for watershed protection and rehabilitation, and measures for water management–are present in varying degrees of intensity according to land use. About 34,531 acres are devoted to cropland use at the present time; 385,450 acres are in forest (including some areas of non-forested land); 1,016 acres are classified as rangeland; and 12,630 acres are in intensive uses. According to Appendix VII, Irrigation, 2,500 acres were under irrigation in 1966.

## ESTIMATED FUTURE NEEDS

Determination of needs is made on the basis of multiple-use management and the categories of floodwater damage reduction. Watershed protection and rehabilitation measures, and water management contain the practices needed for development under the concept. Development needed in forestry and farming is to keep pace with other needs as the population increases and reach the level required by 2020.

Future needs are given in acres of land to be treated. Intensity or degree of practice application will increase with use. Management practices for enhancement of multiple-use objectives may require several practices on the same acre of land. A partial listing of practices used is given in Tables 2-18 and 2-19 in the Puget Sound Area section of this Appendix under Means to Satisfy Needs.

The projected rapid rise in population, with its requirements for space, recreation, accelerated production of food and fiber, and other land and water needs, makes it necessary to initiate an early action program of development to avoid costly misuse of the land resource. An obvious need in this Basin is for improved floodwater damage reduction on the Stillaguamish River as described in Appendix XII, Flood Control, and for flood prevention and drainage facilities to be installed on two small watersheds considered to be in need of improvement to accommodate orderly development of the basins. Details of these early action projects are found in the Means to Satisfy Needs section.

Projections indicate that the Stillaguamish Basin will remain largely agricultural with some intensive land use development in the western region in the vicinity of Arlington. The estimated number of acres, according to land use, that will require protective and development measures by the years 1980, 2000, and 2020 are tabulated in Table 5-4. The same land area may require more than one of these practices.

**TABLE 5-4. Future needs for watershed management [1]**

| Year | Floodwater Damage[2] Reduction[3] (acres) | Watershed Protection & Rehab.[3] (acres) | Drainage Improvement[3] (acres) | Irrigation Development[3] [4] (acres) |
|---|---|---|---|---|
| Cropland | | | | |
| 1980 | 23,075 | 35,547[5] | 13,541 | 11,675 |
| 2000 | 23,075 | 35,547[5] | 22,568 | 16,670 |
| 2020 | 23,075 | 36,016[5] | 30,091[6] | 30,000 |
| Intensive Land Use | | | | |
| 1980 | 1,470 | 12,630 | 12,630 | 0 |
| 2000 | 1,470 | 12,630 | 12,630 | 0 |
| 2020 | 1,470 | 12,967 | 12,967 | 0 |
| Forested Land[7] | | | | |
| 1980 | 0 | 385,450 | 0 | 0 |
| 2000 | 0 | 385,450 | 0 | 0 |
| 2020 | 0 | 384,644 | 0 | 20,600[8] |

[1] Acreages derived by map measurements and ADP tabulation for the PS&AW study. Other potential not tabulated. Unrounded figures do not denote accuracy beyond the first three significant figures.

[2] Includes overbank flooding of main streams.

[3] Needed for full agricultural development (see Appendix V, Water Related Land Resources, chapter 2, Agriculture).

[4] According to Appendix VII, Irrigation, there were 2,500 acres (using 4,800 acre feet of water) irrigated in 1966. Irrigation Appendix projections show 6,500 acres irrigated by 1980, 10,500 acres by 2000, and 10,500 acres by 2020.

[5] Includes 1,016 acres of rangeland.

[6] Does not agree with Table 5-3 due to land use changes during time lapse.

[7] Includes some non-forested land commonly associated with forests.

[8] Potential irrigation of forests (see Appendix V, chapter 3, Forestry).

Table 5-5 shows drainage groups in the watersheds of the Stillaguamish Basin, with the acreage of land falling into each drainage group. From this and other data the drainage needs for expected land uses in the Basin is derived.

**TABLE 5-5. Drainage groups in Stillaguamish Basin[1] (in acres)[2]**

| LINE | Watershed Area No.[3] | River Basins And Watersheds | 01 | 02 | 03 | 04 | 05 | 06 | 07 | 08 | 09 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Puget Sound Drainages | | | | | | | | | | | | | | | | | |
| 1 | 0-17 | No. Fork Stillaguamish | 7,268 | 0 | 767 | 20 | 0 | 545 | 0 | 406 | 0 | 0 | 3,179 | 75 | 0 | 95 | 0 | 678 | 13,032 |
| 2 | 0-18 | S. Fork Stillaguamish | 1,498 | 0 | 1,217 | 45 | 0 | 409 | 0 | 195 | 0 | 0 | 6,675 | 209 | 0 | 15 | 0 | 460 | 10,723 |
| 3 | 0-19 | Jim Creek | 555 | 0 | 120 | 0 | 0 | 631 | 285 | 64 | 0 | 0 | 1,956 | 54 | 0 | 5 | 0 | 95 | 3,764 |
| 4 | 0-20 | Pilchuck Creek | 833 | 0 | 763 | 0 | 0 | 975 | 0 | 20 | 55 | 35 | 14,009 | 510 | 0 | 140 | 0 | 10 | 17,350 |
| 5 | 0-21 | Lower Stillaguamish | 10,340 | 0 | 1,652 | 446 | 0 | 2,595 | 0 | 296 | 0 | 0 | 10,263 | 50 | 0 | 384 | 0 | 571 | 26,596 |
| 6 | 0-22 | Church Creek | 2,177 | 0 | 215 | 150 | 0 | 1,720 | 0 | 45 | 0 | 0 | 2,572 | 0 | 0 | 20 | 0 | 494 | 7,393 |
| 7 | | Total | 22,671 | 0 | 4,734 | 661 | 0 | 6,875 | 285 | 1,024 | 55 | 35 | 38,653 | 898 | 0 | 659 | 0 | 2,308 | 78,858 |
| 8 | | Grand Total | 22,671 | 0 | 4,734 | 661 | 0 | 6,875 | 285 | 1,024 | 55 | 35 | 38,653 | 898 | 0 | 659 | 0 | 2,308 | 78,858 |

[1] Descriptions of drainage groups are found in the Means to Satisfy Needs section of the Area report.

[2] Unadjusted measurements, 1966, for Puget Sound Area Study. Tabulations by ADP. Read three significant figures.

[3] See Figures 5-1 for location.

# MEANS TO SATISFY NEEDS

Population forecasts predict approximately 77,800 people in the Stillaguamish Basin by 2020. The means used to accomplish the levels necessary to meet the needs of this expected population consist of programs and projects for protection and development of the land and water resources of this Basin. The wise use and development of these resources can supply the spatial needs and aesthetic wants required by a growing population. The needs as developed in other appendices have been considered in this Appendix as being related to the land and water resources of the Basin.

The objectives of the plan for watershed management are to develop the Basin's resources to achieve its potential production of food and fiber as economically justified, to preserve and enhance fish, wildlife, and recreation values in accord with the Fish and Wildlife, and Recreation Appendices, to provide for development of urban areas not subject to floodwater hazard, and to provide spatial needs in keeping with aesthetic qualities of the area. These objectives will be carried out by various agencies of the Federal and State governments working in close cooperation with each other and with private sources.

## Land Use

Table 5-1 in Present Status indicates by subbasin the present land use. Table 5-6 summarizes by time periods the estimated future use of the land.

## Flooding

Floodwater damage must be prevented to the

**TABLE 5-6. Estimated future land use**

| Year | Cropland (acres) | Rangeland (acres) | Forest[1] (acres) | Urban Built-up[2] (acres) | Fresh water (acres) | Total (acres) |
|---|---|---|---|---|---|---|
| 1980 | 34,531 | 1,016 | 385,450 | 12,630 | 4,721 | 438,348 |
| 2000 | 34,531 | 1,016 | 385,450 | 12,630 | 4,721 | 438,348 |
| 2020 | 35,000 | 1,016 | 384,644 | 12,967 | 4,721 | 438,348 |

[1] Includes non-forested land normally associated with forest.

[2] Rural non-farm is assumed to be all urban by 1980. Built-up based on average urban density of six persons per acre.

extent the hazard remaining does not materially exceed other risks before development becomes practical. Loss is limited to tolerable values by restricting development on hazardous areas.

Watersheds require varied combinations and intensities of management according to the capability of the land and its use. Programs are planned to stabilize land and related water and thus benefit most functional uses of water. Special objectives for improvement may be selected for project purposes.

## PLAN OF DEVELOPMENT

This plan to provide for satisfaction of the needs will utilize the program and project approach, as explained in the Puget Sound Area section. The plan will guide the development of the resources of the Stillaguamish Basin to provide for spatial and production requirements for the expected population of its service area to the year 2020. Floodwater prevention and low flow augmentation projects would benefit fish, wildlife, and recreation areas on the North Fork of the Stillaguamish and its tributaries, Boulder River and Squire, French, and Deer Creeks. Other streams that would benefit from these projects include Jim, Pilchuck and Portage Creeks.

### Early Action Projects

Several projects will be initiated prior to 1980 to remedy existing floodwater and drainage problems and to develop lands toward their potential for continued use. Following are descriptions of projects in the early action plan as listed in Table 5-7.

**Lower Stillaguamish Watershed Area 0-21, Figure 5-1** is located on both sides of the Stillaguamish River and extends from the mouth to and including the city of Arlington. The flood plain of the Stillaguamish downstream from Arlington is primarily agricultural. The other principal agricultural area is the high terrace area south and west of Arlington. Outside the Stillaguamish flood plain most of the area is forest land. Pilchuck Creek drainage, in particular, has extensive tree farms and Douglas-fir and western hemlock are the principal commercial species. Some of the best red alder sites anywhere are found in the lower elevations of this watershed. On the uplands of the lower watershed there are many lakes which are attractive because of their forest setting. The forest situation in this watershed has to be reviewed on the basis of many uses and intent of ownership. A study is needed to evaluate the varied conditions in this watershed in relationship to soil and water resources.

The project is designed for flood prevention of agricultural and urban areas, and drainage of agricultural lands. The area contains 8,522 acres of which 5,578 acres are cropland, 1,794 acres are forest, 872 acres rural non-farm and urban, and 278 acres miscellaneous uses. Lowlands should remain in open use.

The works of improvement will consist of 17 miles of improved and stabilized channel, three outlet structures consisting of floodgates and pumps, and one mile of new reconstructed dike.

Installation cost is estimated to be $980,355, of which the Federal share is $671,535, and the local share is $308,820. Benefits from damage reduction and drainage will provide a benefit-cost ratio of 3.2 to 1. To achieve benefits made possible by the structural works and other management during a 15-year period, local interests will install necessary land treatment measures for erosion control and flood management, costing approximately $400,365, drain-

**TABLE 5-7. Costs and benefited areas, early action projects recommended for installation by 1980**

| Watershed Area No. And Name[1] | Project Area | Structural Measures Installation Cost[2] | Floodwater Protection | Drainage Improvement |
|---|---|---|---|---|
| | (acres) | (dollars) | (acres) | (acres) |
| 0-21 Lower Stillaguamish R.[3] | 8,522 | 980,000 | 5,547 | 5,422 |
| 0-22 Church Creek | 8,060 | 665,000 | 2,732 | 4,424 |
| Total | 16,582 | 1,645,000 | 8,279 | 9,846 |

[1] See Figure 5-1 for location.
[2] 1967 prices.
[3] Part of watershed.

age measures expected to cost $1,177,170, and forest protection and management practices costing $37,477, for a total of $1,615,012. The total cost of installing the structural measures and the land treatment measures is $2,595,367.

**Church Creek Watershed Area 0-22, Figure 5-1** is located in northwest Snohomish County and includes the city of Stanwood. The stream outlets into both Skagit Bay and Port Susan Sound. The lower portion of the watershed can be, and occasionally is, flooded by either the Skagit River or the Stillaguamish River in addition to flooding from heavy precipitation falling within the area. Flooding and drainage are also problems on the uplands.

The upland area has over 50 percent forest land in scattered tracts. Many of these have been logged, relogged, and cleared of wood until only a stand of native brush remains. The principal species are mixed stands of Douglas-fir and red alder, with some western hemlock, western red cedar, and big leaf maple. This upland country offers the best homesites and where wood fiber is not the main interest to the owner, measures should be advocated which improve the landscape and safeguard the water and wildlife resources.

The project is feasible for flood prevention of agricultural and urban areas, and drainage of agricultural lands. The area contains 8,060 acres of which 4,431 ares are cropland, 1,706 acres are forest, 1,467 acres rural non-farm and urban, and 456 acres miscellaneous uses.

The works of improvement will consist of 8 miles of improved and stabilized channel, three outlet structures consisting of floodgates and pumps, and 1 mile of new and reconstructed dike.

Installation cost is estimated to be $664,695, of which the Federal share is $477,470, and the local share is $186,955. Benefits from damage reduction and drainage will provide a benefit-cost ratio of 3.1 to 1. To achieve benefits made possible by the structural works and other management during a 15-year period local interests will install necessary land treatment measures for erosion control and flood management, costing approximately $318,038, drainage measures estimated to cost $849,494, and forest protection and management practices costing $35,639, for a total of $1,203,171. The total cost of installing the structural measures and the land treatment measures is $1,867,866.

## Projects after 1980

Projects for the years 1980-2000 and 2000-2020 are shown in Table 5-8 with their expected costs. Benefits and benefit-cost ratios have not been computed past 1980. Total installation costs are expected to be $6,930,000.

**TABLE 5-8. Costs of projects recommended for installation after 1980.**

| Watershed Area No. and Name[1] | Project Area (acres) | Struc. Meas. Installation Cost[2] (dollars) |
|---|---|---|
| **1980-2000** | | |
| 0-20 Pilchuck Creek | 48,809 | 300,000 |
| 0-21 Lower Stillaguamish River | 29,492 | 4,320,000 |
| 0-22 Church Creek | 8,060 | 1,000,000 |
| Total | 86,361 | 5,620,000 |
| **2000-2020** | | |
| 0-17 North Fork Stillaguamish | 180,594 | 860,000 |
| 0-18 South Fork Stillaguamish | 128,843 | 350,000 |
| 0-19 Jim Creek | 29,307 | 100,000 |
| Total | 338,744 | 1,310,000 |

1 See Figure 5-1 for location

2 1967 prices.

## Programs

Program measures refer to on-farm and urban on-site practices which take advantage of improvements made possible by the structural works of improvement, as well as measures for watershed protection, erosion control, and water management. These measures will include seeding of improved grasses and legumes, cover crops, cropland and urban drainage development made possible by structural works of improvement, forest management practices, and irrigation development.

Table 5-9 shows a breakdown of the various practices for each of the three time periods.

## Summary of Costs

Costs for the Stillaguamish Basin plan (project costs plus program costs, rounded to the nearest thousand dollars) are expected to be $30,338,000 for the early action programs; $35,100,000 for the years 1980-2000; and $29,857,000 for the years 2000 through 2020. Total cost of the plan will be $95,295,000. See page 2-89 et seq.; also page 2-95, Table 2-20, for further information on costs.

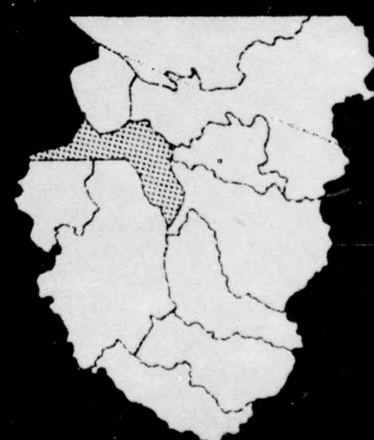
TABLE 5-9. Watershed management practices for protection and development, by time periods, Stillaguamish Basin

| Practice | Area (acres) | | Cost[1] (thousands of dollars) |
|---|---|---|---|
| First 15 Years | | | |
| Technical assistance & management | 420,997[2] | | 7,435 |
| Federal, regular | | 7,377 | |
| Federal, accelerated | | 58 | |
| Installation of practices (non-Federal) | | | 21,258 |
| State & corporate management | | 5,325 | |
| Land treatment | 245,816 | 3,524 | |
| Water management | 13,541 | 4,814 | |
| Urban drainage | 5,626 | 7,595 | |
| Total | | | 28,693 |
| 1980-2000 | | | |
| Technical assistance & management | 420,997[2] | | 9,891 |
| Federal, regular | | 9,776 | |
| Federal, accelerated | | 115 | |
| Installation of practices (non-Federal) | | | 18,589 |
| State & corporate management | | 7,100 | |
| Land treatment | 245,816 | *4,339 | |
| Water management | 9,027 | *2,925 | |
| Urban drainage | 3,870 | *5,225 | |
| Total | | | 29,480 |
| 2000-2020 | | | |
| Technical assistance & management | 420,660[2] | | 8,108 |
| Federal, regular | | 7,993 | |
| Federal, accelerated | | 115 | |
| Installation of practices (non-Federal) | | | 20,439 |
| State & corporate management | | 7,100 | |
| Land treatment | 245,479 | *4,338 | |
| Water management | 13,330 | *4,315 | |
| Urban drainage | 3,471 | *4,686 | |
| Total | | | 28,547 |

1 Base: 1967 prices, except items asterisked which are 1967 adjusted normalized prices. See page 2-89 et seq. for further explanation of costs.

2 Total acres in basin involved in program measures.

# Whidbey-Camano Islands



# WHIDBEY-CAMANO ISLANDS

The Whidbey-Camano Islands study area is comprised of all of Island County. Island County is located at the northern end of Puget Sound, off the coast of Skagit and Snohomish Counties.

Two large islands and three small islands combine to form the Whidbey-Camano Islands study area. The major islands are Whidbey, the largest and most important, draining an area of 169 square miles, and Camano draining an area of 40 square miles. The three smaller islands are Ben Ure, Strawberry, and Smith.

## PRESENT STATUS

In 1963 the population was 19,900, and projections of population indicate that by 1980 it will be 26,900; by 2000, 36,200; and by the year 2020 will reach 49,500. Population density at the present time, figured on rural and non-farm lands, is 0.85 people per acre.

Farming is concentrated largely in the northern half of Whidbey Island. Shifts in land use have not been extreme. The raising of beef cattle has more or less replaced dairying. The raising of hay, wheat, oats, vegetables, and other specialized crops is highly important in the Areas' economy. The total number of farms and acreage has decreased with lands formerly cropped being taken over by the military and naval sites. Total value of farm production in the Whidbey-Camano Islands is almost $3 million annually.

Forests are the largest use of the land in the Islands. Lumbering is a significant factor in the economy of the Islands. Forested lands, including associated open areas, comprise 84,000 acres.

Lumbering, farming, recreation, and the military establishments form the base of the Area's economy. There are no large industrial establishments on the Islands. Most forest and cropland products are processed elsewhere.

The economy of the Islands is directly benefitted by the commercial and sport fisheries for salmon throughout the marine waters. The streams of the Islands support only minor populations of anadromous fish.

The numerous sheltered bays and extensive salt water shoreline provide ideal resting areas for wintering waterfowl. The low rainfall and mild climate are particularly beneficial to the production and survival of upland game. Fur-bearing animal populations are somewhat limited although varying numbers of beaver, muskrat, mink, etc. are present. The only big game, and by far the most important game species in the Islands, is the black-tailed deer.

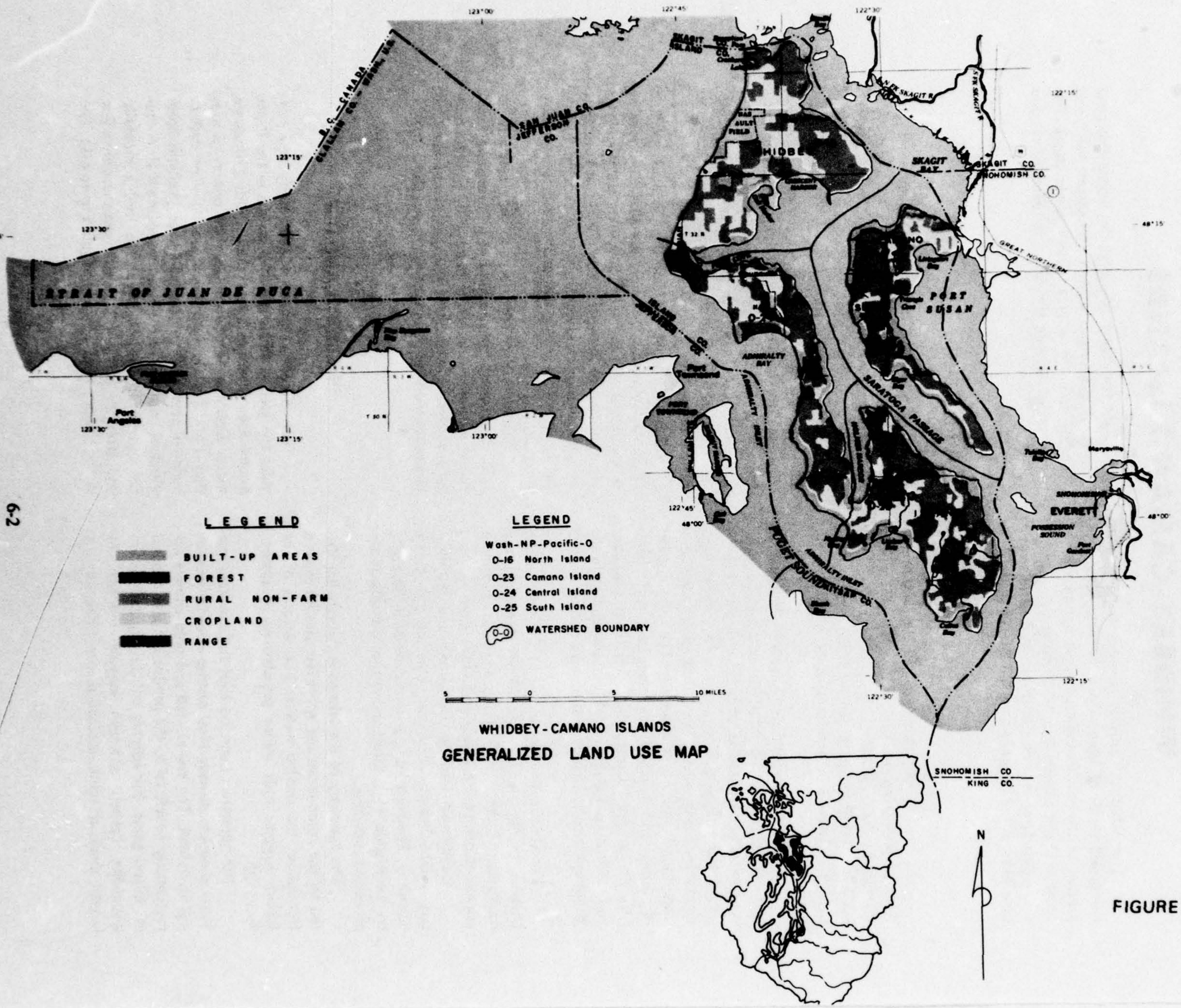
The Islands provide an outstanding environment for recreation and a base for salt water fishing and other outdoor activities. Their extensive shorelines and excellent beaches, resorts, pleasant roads, charming towns and older buildings, historic sites, large naval installations at Ault Field and Oak Harbor, and spectacular Deception Pass attract many visitors. In addition the favorable climate is attractive to recreationists.

Because the Islands lie in the rain shadow of the Olympic Mountains, generally less than 20 inches of precipitation falls annually, and there is virtually no accumulation of snowpack. Because of small amounts of precipitation and small size of stream basins, surface runoff is scanty and many streams flow only intermittently.

Sediment problems occur in only a few localized areas where construction or farming have resulted in erosion owing to the removal of vegetation. A profuse cover of vegetation generally precludes excessive erosion during periods of intensive rain.

### PRESENT LAND USE

The Whidbey-Camano Islands study area provides the second smallest valley system in the Puget Sound Area. It drains a total area of only 210 square miles. Drainage is accomplished by minor streams that flow directly into Puget Sound. The system includes several flood and drainage problem areas which require corrective measures before their potential can be attained. Most of the land is generally undulating to gently rolling, although there are a few slopes steeper than 15 percent (see Figure 6-1). The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B.C. - CANADA
SAN JUAN CO.
JEFFERSON CO.
SKAGIT ISLAND
WHIDBEY
SKAGIT BAY
SKAGIT CO.
SNOHOMISH CO.
GREAT NORTHERN
PORT SUSAN
SARATOGA PASSAGE
ADMIRALTY BAY
ADMIRALTY INLET
PUGET SOUND
Port Townsend
Port Angeles
Marysville
EVERETT
POSSESSION SOUND
SNOHOMISH CO.
KING CO.
123°30'
123°15'
123°00'
122°45'
122°30'
122°15'
48°15'
48°00'
LEGEND
BUILT-UP AREAS
FOREST
RURAL NON-FARM
CROPLAND
RANGE
LEGEND
Wash-NP-Pacific-O
0-16 North Island
0-23 Camano Island
0-24 Central Island
0-25 South Island
WATERSHED BOUNDARY
5 0 5 10 MILES
WHIDBEY-CAMANO ISLANDS
GENERALIZED LAND USE MAP
N

FIGURE 6-1.

ownership distribution of the Islands' lands are shown on Figure 6-2.

The broad categories of land use are given in Table 6-1 which follows. No attempt is made here to quantify multiple-use management of lands such as for game habitat, recreation, water quality, or low flow augmentation.

## SOILS

The mapping units are discussed in the soil survey report for Island County and their locations are shown on maps. The soil survey report is available in libraries and in local offices of the United States Department of Agriculture.

The principal properties of each soil series are tabulated in Exhibit 1, Table 6 of this Appendix. Interpretations of data for each soil series are provided in subsequent tables of the Exhibit.

The total land area of 133,000 acres in the Whidbey-Camano Islands has been mapped by a medium-intensity soil survey. Of the 133,000 acres, 125,200 acres are classified in Land Capability Classes II through VI, 3,400 acres are in Class VII, and 4,400 acres in Class VIII. Lands in Land Use Capability Classes II through VI (125,100 acres) have the greatest potential for development; i.e., changed use or improved use. Land Use Capability Classes II, III and IV may be suited for either crops or urban uses, and Class VI has potential for urban development. Most of the Class II and Class III lands in these Islands are subject to flooding and have wetness conditions which present hazards for many developed uses. Class VII is expected to be largely limited to forest use and Class VIII for recreation or aesthetic use (Figure 6-3).

The soil types in the Area having a medium-intensity survey have been classified into land capability classes and their primary and secondary subclasses, and capability units (see Exhibit 1, Tables 9 and 10).

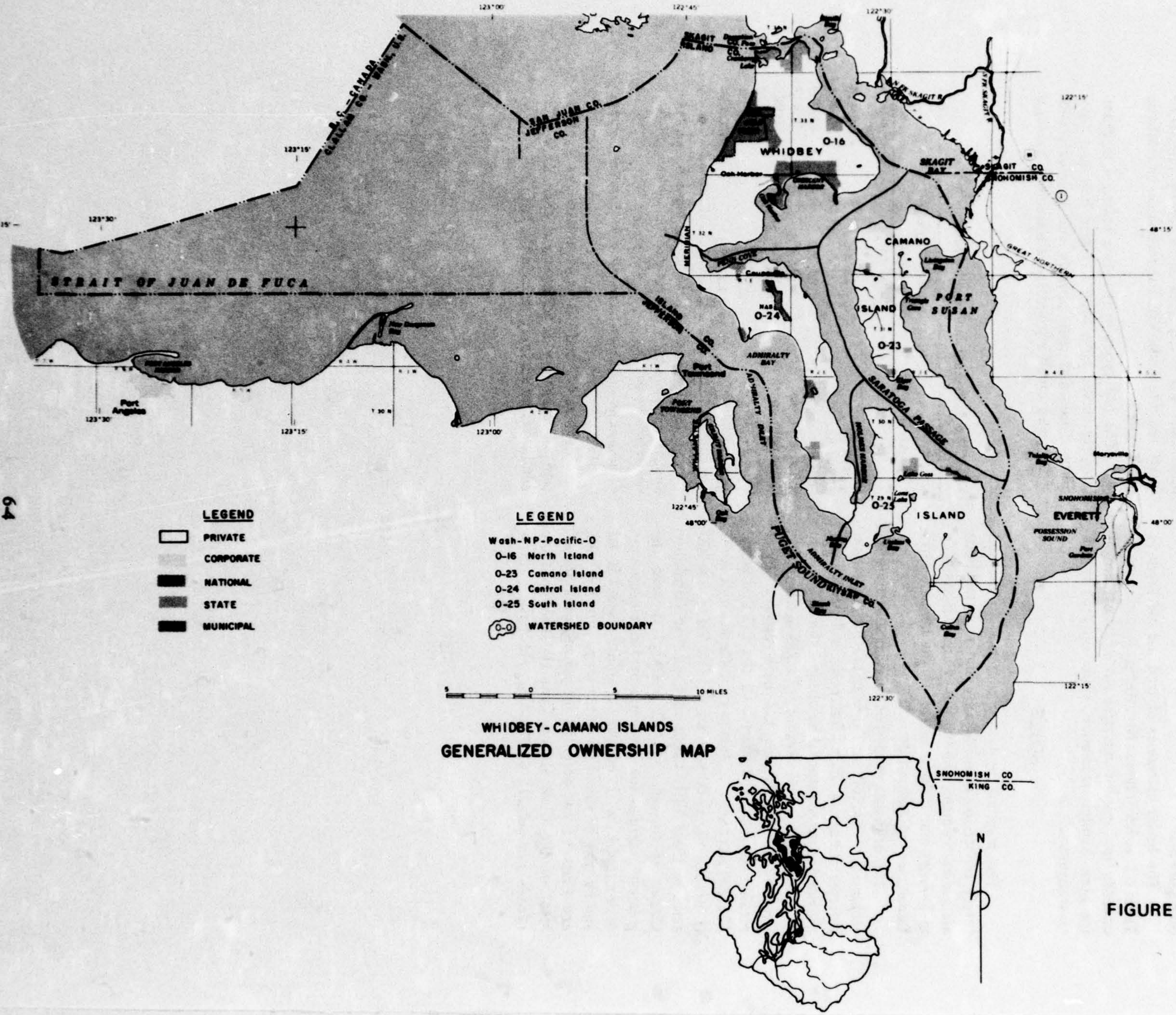
***TABLE 6-1. Present land use by sub-basin*** [1]

| Land Use | Whidbey-Camano Islands (acres) | Total (acres) |
|---|---|---|
| Cropland | 23,006 | 23,006 |
| Rangeland | 2,454 | 2,454 |
| Forest[2] | 84,069 | 84,069 |
| Rural non-farm | 12,419 | 12,419 |
| Urban built-up | 10,987 | 10,987 |
| Fresh water | 719 | 719 |
| Total | 133,654 | 133,654 |

[1] Unadjusted measurements, 1966, for Puget Sound Area Study. Tabulations by ADP. First three figures are significant figures for acreages.

[2] Includes non-forested land normally associated with forest.

Tables 6-2 and 6-3 which follow give a tabulation of capability subclasses and specific wetness conditions for surveyed lands in the Islands.




WHIDBEY-CAMANO ISLANDS

GENERALIZED OWNERSHIP MAP

FIGURE 6-2.

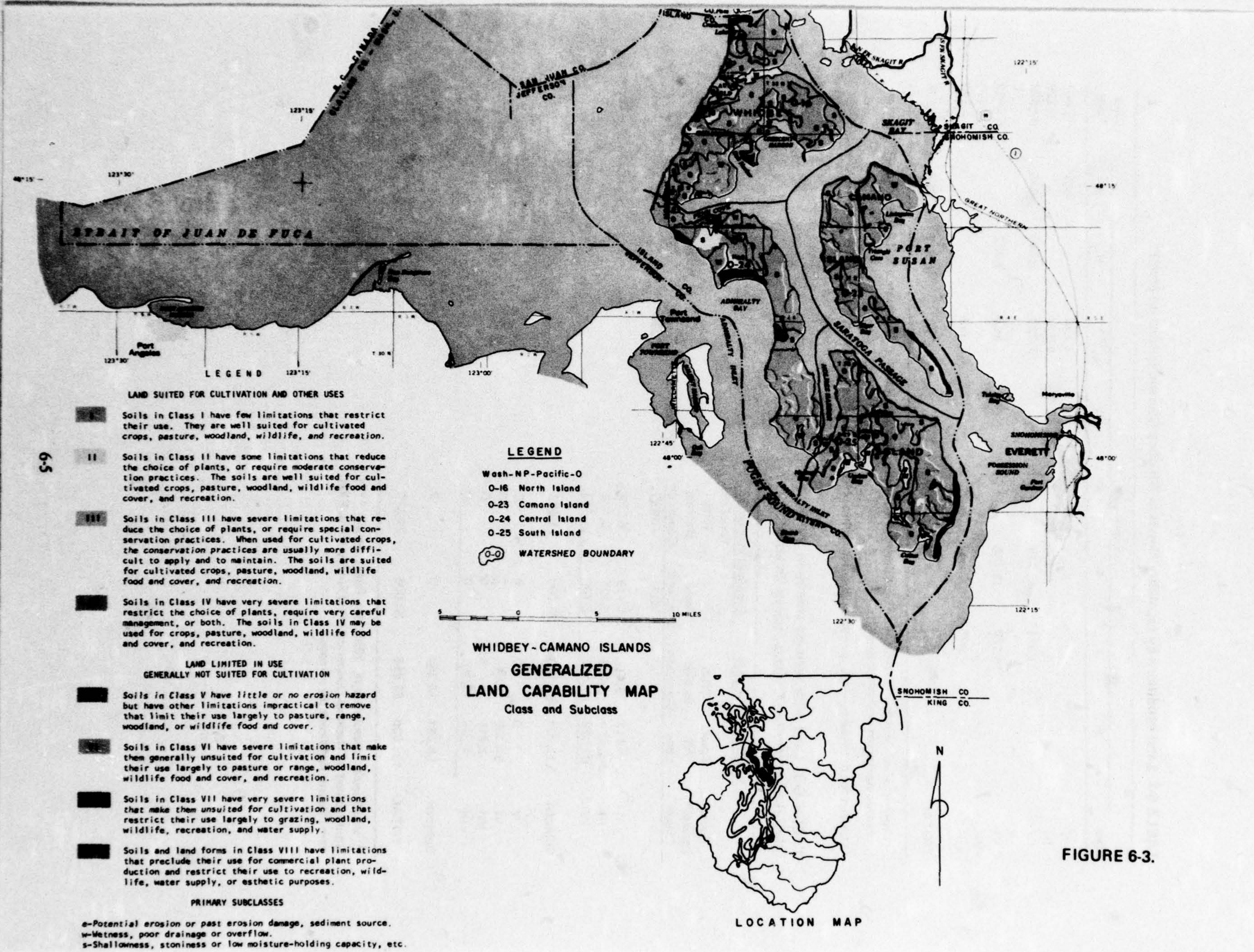

STRAIT OF JUAN DE FUCA
SAN JUAN CO.
JEFFERSON CO.
ISLAND CO.
JEFFERSON CO.
SKAGIT BAY
SKAGIT CO.
SNOHOMISH CO.
GREAT NORTHERN
CAMANO
PORT SUSAN
SARATOGA PASSAGE
ADMIRALTY BAY
ADMIRALTY INLET
PUGET SOUND RIVERS CO.
Port Townsend
Port Angeles
EVERETT
POSSESSION SOUND
Marysville
123°30'
123°15'
123°00'
122°45'
122°30'
122°15'
48°15'
48°00'
LEGEND
LAND SUITED FOR CULTIVATION AND OTHER USES
I Soils in Class I have few limitations that restrict their use. They are well suited for cultivated crops, pasture, woodland, wildlife, and recreation.
II Soils in Class II have some limitations that reduce the choice of plants, or require moderate conservation practices. The soils are well suited for cultivated crops, pasture, woodland, wildlife food and cover, and recreation.
III Soils in Class III have severe limitations that reduce the choice of plants, or require special conservation practices. When used for cultivated crops, the conservation practices are usually more difficult to apply and to maintain. The soils are suited for cultivated crops, pasture, woodland, wildlife food and cover, and recreation.
Soils in Class IV have very severe limitations that restrict the choice of plants, require very careful management, or both. The soils in Class IV may be used for crops, pasture, woodland, wildlife food and cover, and recreation.
LAND LIMITED IN USE
GENERALLY NOT SUITED FOR CULTIVATION
Soils in Class V have little or no erosion hazard but have other limitations impractical to remove that limit their use largely to pasture, range, woodland, or wildlife food and cover.
Soils in Class VI have severe limitations that make them generally unsuited for cultivation and limit their use largely to pasture or range, woodland, wildlife food and cover, and recreation.
Soils in Class VII have very severe limitations that make them unsuited for cultivation and that restrict their use largely to grazing, woodland, wildlife, recreation, and water supply.
Soils and land forms in Class VIII have limitations that preclude their use for commercial plant production and restrict their use to recreation, wildlife, water supply, or esthetic purposes.
PRIMARY SUBCLASSES
e-Potential erosion or past erosion damage, sediment source.
w-Wetness, poor drainage or overflow.
s-Shallowness, stoniness or low moisture-holding capacity, etc.
LEGEND
Wash-NP-Pacific-O
0-16 North Island
0-23 Camano Island
0-24 Central Island
0-25 South Island
0-0 WATERSHED BOUNDARY
5 0 5 10 MILES
WHIDBEY-CAMANO ISLANDS
GENERALIZED
LAND CAPABILITY MAP
Class and Subclass
SNOHOMISH CO.
KING CO.
N
LOCATION MAP

FIGURE 6-3.

**TABLE 6-2. Land conditions by capability classes in Whidbey-Camano Islands (in acres)** [1]

| Class | Subclasses[2] e | w | s | ew | es | we | ws | se | sw | Class Total |
|---|---|---|---|---|---|---|---|---|---|---|
| II | | | | | | | 4,796 | | 651 | 5,447 |
| III | | | | 156 | | | 6,073 | | | 6,229 |
| IV | | | 1,531 | 49,777 | 725 | | 7,320 | 2,340 | 335 | 62,028 |
| V | | | | | | | | | | 0 |
| VI | | | 19,179 | 12,145 | 11,641 | | 502 | 7,972 | | 51,439 |
| VII | | | | | 3,416 | | | | | 3,416 |
| VIII | | | 675 | 2,042 | | | 1,659 | | | 4,376 |
| TOTAL | | | 21,385 | 64,120 | 15,782 | | 20,350 | 10,312 | 986 | 132,935 |

[1] Unadjusted measurements, 1966, for Puget Sound Area Study, based on National Cooperative Soil Survey maps. First three figures are significant figures for acreages.

[2] Letters for subclasses denote hazards or conditions that affect land use and treatment: e—erosion; w—wetness; s—soil.

**TABLE 6-3. Land with wetness condition by capability classes, Whidbey-Camano Islands (in acres)** [1]

| Land Capability Classes | All land in islands: Total All Land | With Wetness Condition | Cropland in islands: Total Cropland (est.) | Cropland With Wetness Condition (est.) |
|---|---|---|---|---|
| II | 5,447 | 5,447 | 5,175 | 5,175 |
| III | 6,229 | 6,229 | 5,125 | 5,125 |
| IV | 62,028 | 57,432 | 12,706 | 11,373 |
| Subtotal | 73,704 | 69,108 | 23,006 | 21,673 |
| V | 0 | 0 | 0 | 0 |
| VI | 51,439 | 12,647 | 0 | 0 |
| VII | 3,416 | 0 | 0 | 0 |
| VIII | 4,376 | 3,701 | 0 | 0 |
| Subtotal | 59,231 | 16,348 | 0 | 0 |
| TOTAL | 132,935 | 85,456 | 23,006 | 21,673 |

[1] Unadjusted measurements, 1966, for Puget Sound Area Study, based on National Cooperative Soil Survey maps. First three figures significant for acreages.

# PRESENT AND FUTURE NEEDS

## EVALUATION OF PRESENT SITUATION

In the Whidbey-Camano Islands three broad categories of needs—protection from floodwater damage, measures for watershed protection and rehabilitation, and measures for water management—are present in varying degrees of intensity according to land use. About 23,006 acres are now used for cropland; 84,069 acres are in forest (including some areas of non-forested land); 2,454 acres are in rangeland; and 23,406 acres are in more intensive uses. According to Appendix VII, Irrigation, 2,700 acres were under irrigation in these Islands in 1966.

## ESTIMATED FUTURE NEEDS

Determination of needs is made on the basis of multiple-use management and the categories of floodwater damage reduction. Watershed protection and rehabilitation measures, and water management contain the practices needed for development under the concept. Development needed in forestry and farming is to keep pace with other needs as the population increases and reach the level required by 2020.

Future needs are given in acres of land to be treated. Intensity of degree of practice application will increase with use. Management practices for enhancement of multiple-use objectives may require several practices on the same acre of land. A partial listing of practices used is given in Tables 2-18 and 2-19 in the Puget Sound Area section of this Appendix under Means to Satisfy Needs.

Although the Islands are expected to increase in population, this increase will not be rapid enough to necessitate any early action projects. All projects for flood prevention and drainage will occur in later time periods as the need develops. A summation of these projects can be found in the Means to Satisfy Needs section of these Islands.

Only small amounts of urban expansion are expected to take place in the Whidbey-Camano Islands. The estimated number of acres by land use that will require protection and development measures by the years 1980, 2000, and 2020 are tabulated in Table 6-4. Any acre may require more than one of these practices.

**TABLE 6-4. Future needs for watershed management [1]**

| Year | Floodwater Damage[2] Reduction[3] (acres) | Watershed Protection & Rehab.[3] (acres) | Drainage Improvement[3] (acres) | Irrigation Development[4] (acres) |
|---|---|---|---|---|
| **Cropland** | | | | |
| 1980 | 20,000 | 24,960[5] | 8,632 | 3,500 |
| 2000 | 20,000 | 24,210[5] | 14,387 | 5,000 |
| 2020 | 20,000 | 22,454[5] | 19,182 | 10,000 |
| **Intensive Land Use** | | | | |
| 1980 | 4,560 | 23,406 | 23,406 | 0 |
| 2000 | 4,560 | 23,406 | 23,406 | 0 |
| 2020 | 4,560 | 23,406 | 23,406 | 0 |
| **Forested Land[7]** | | | | |
| 1980 | 0 | 84,069 | 0 | 0 |
| 2000 | 0 | 84,069 | 0 | 0 |
| 2020 | 0 | 84,069 | 0 | 0 |
| **Unclassified Land** | | | | |
| 1980 | 0 | 500 | 0 | 0 |
| 2000 | 0 | 1,250 | 0 | 0 |
| 2020 | 0 | 3,006 | 0 | 0 |

1 Acreages derived by map measurements and ADP tabulation for the PS&AW study. Other potential not tabulated. Unrounded figures do not denote accuracy beyond the first three significant figures.

2 Includes overbank flooding of main streams.

3 Needed for full agricultural development (see Appendix V, Water-Related Land Resources, chapter 2, Agriculture).

4 According to Appendix VII, Irrigation, there were 2,700 acres (using 7,398 acre feet of water) irrigated in 1966. Irrigation Appendix projections show that irrigation will decline in future years in the Islands.

5 Includes 2,454 acres of rangeland.

6 Does not agree with Table 6-3 due to land use changes during time lapse.

7 Includes some non-forested land commonly associated with forests.

Table 6-5 shows drainage groups in the watershed of the Whidbey-Camano Islands, with the acreage of land falling into each drainage group. From this and other data the drainage needs for expected land uses in the Islands are derived.

**TABLE 6-5. Drainage groups in Whidbey-Camano Islands[1] (in acres)[2]**

| LINE | Watershed Area No[3] | River Basins and Watersheds | 01 | 02 | 03 | 04 | 05 | 06 | 07 | 08 | 09 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Puget Sound Drainages | | | | | | | | | | | | | | | | | |
| 1 | 0-16 | North Island | 1,209 | 2,313 | 858 | 0 | 0 | 1,076 | 0 | 0 | 1,982 | 0 | 16,259 | 796 | 0 | 193 | 0 | 101 | 24,787 |
| 2 | 0-23 | Camano Island | 816 | 54 | 83 | 0 | 0 | 445 | 0 | 0 | 725 | 2,800 | 12,343 | 178 | 0 | 0 | 0 | 316 | 17,760 |
| 3 | 0-24 | Central Island | 461 | 1,431 | 99 | 0 | 0 | 357 | 0 | 0 | 1,837 | 0 | 13,828 | 103 | 0 | 772 | 0 | 944 | 19,832 |
| 4 | 0-25 | South Island | 964 | 0 | 969 | 0 | 0 | 1,225 | 0 | 0 | 297 | 0 | 18,985 | 356 | 0 | 155 | 0 | 126 | 23,077 |
| 5 | | Total | 3,450 | 3,798 | 2,009 | 0 | 0 | 3,103 | 0 | 0 | 4,841 | 2,800 | 61,415 | 1,433 | 0 | 1,120 | 0 | 1,487 | 85,456 |
| 6 | | Grand Total | 3,450 | 3,798 | 2,009 | 0 | 0 | 3,103 | 0 | 0 | 4,841 | 2,800 | 61,415 | 1,433 | 0 | 1,120 | 0 | 1,487 | 85,456 |

[1] Descriptions of drainage groups are found in the Means to Satisfy Needs section of the Area report.

[2] Unadjusted measurements, 1966, for Puget Sound Area Study. Tabulations by ADP. Read three significant figures.

[3] See Figure 6-1 for location.

# MEANS TO SATISFY NEEDS

Projections indicate that by the year 2020, 49,500 people will reside in the Whidbey-Camano Islands. The means to be used to achieve the levels necessary to meet the needs of this expected population consist of programs and projects for protection and development of the land and water resources found herein. The wise use and development of these resources can supply the spatial needs and aesthetic wants of the growing population in these Islands. The needs as developed in other appendices have been considered in this Appendix as related to the land and water resources of the Islands.

The objectives of the plan for watershed management are to develop the Islands' resources to achieve their potential production of food and fiber as economically justified; to preserved and enhance fish, wildlife, and recreation values in accord with the Fish and Wildlife, and Recreation Appendices, to provide for development of urban areas not subject to floodwater hazard, and to provide spatial needs in keeping with aesthetic qualities of the area. These objectives will be carried out by various agencies of the Federal and State governments working in close cooperation with each other and with private sources.

## Land Use

Table 6-1 in Present Status indicates present land use. Table 6-6 summarizes by time periods the estimated future use of the land.

## Flooding

Floodwater damage must be prevented to the extent the hazard remaining does not materially exceed other risks before development is practical. Loss is limited to tolerable levels by restricting intensive use of land in hazardous areas, followed by feasible damage prevention and enhancement measures for suitable use.

**TABLE 6-6. Estimated future land use**

| Year | Crop-land (acres) | Range-land (acres) | Forest[1] (acres) | Urban Built-up[2] (acres) | Fresh water (acres) | Misc. Uses[3] (acres) | Total (acres) |
|---|---|---|---|---|---|---|---|
| 1980 | 22,506 | 2,454 | 84,069 | 23,406 | 719 | 500 | 133,654 |
| 2000 | 21,756 | 2,454 | 84,069 | 23,406 | 719 | 1,250 | 133,654 |
| 2020 | 20,000 | 2,454 | 84,069 | 23,406 | 719 | 3,006 | 133,654 |

[1] Includes non-forested land normally associated with forest.

[2] Rural non-fram is assumed to all urban by 1980. Built-up based on average urban density of six persons per acre.

[3] Unspecified uses, including land in transitional usage.

## PLAN OF DEVELOPMENT

This plan to provide for the satisfaction of the needs as brought out in the Needs discussion will utilize the program and project approach, as explained in the Puget Sound Area section. The plan will guide the development of the resources of the Whidbey-Camano Islands to provide for spatial and production requirements for the expected population of its service area to the year 2020. The Islands offer opportunities for projects and programs that could maintain and increase fish and wildlife production. In addition, a number of opportunities exist for development of facilities to meet increased recreation demands. No projects are deemed necessary until after 1980 in these Islands.

### Projects after 1980

Several projects will be initiated in the 1980-2000 time period to remedy existing floodwater and drainage problems and to develop lands toward their potential for continued use. Benefits and benefit-cost ratios have not been computed for projects past 1980. Table 6-7 shows brief summaries of projects included in this plan:

**TABLE 6-7. Costs of projects recommended for installation after 1980**

| Watershed Area No. and Name[1] | Project Area (acres) | Struc. Meas. Installation Costs[2] (dollars) |
|---|---|---|
| 0-16 North Island | 40,472 | 1,300,000 |
| 0-23 Camano Island | 25,264 | 375,000 |
| 0-24 Central Island | 30,310 | 800,000 |
| 0-25 South Island | 36,889 | 770,000 |
| Total | 132,935 | 3,245,000 |

[1] See Figure 6-1 for location.

[2] 1967 prices.

### Programs

Program measures refer to on-farm and urban on-site practices which take advantage of improvements made possible by the structural works of improvement, as well as measures for watershed protection, erosion control, and water management. These measures will include seeding of improved grasses and legumes, cover crops, cropland and urban drainage development made possible by structural works of improvement, forest management practices, and irrigation development.

Table 6-8 shows a breakdown of the various practices for each of the three time periods.

### Summary of Costs

Costs for the Whidbey-Camano Islands plan (project costs plus program costs, rounded to the nearest thousand dollars) are expected to be \$16,266,000 for the first fifteen years, \$21,657,000 for the years 1980-2000, and \$19,642,000 for the years 2000 through 2020. Total cost of the plan will be \$57,565,000. See page 2-89 et seq. for further explanation of costs.

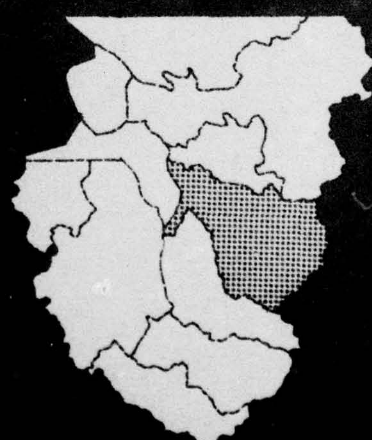
**TABLE 6-8. Watershed management practices for protection and development, by time periods, Whidbey-Camano Islands**

| Practice | Area (acres) | | Costs[1] (thousand of dollars) |
|---|---|---|---|
| **First 15 Years** | | | |
| Technical assistance & management | 109,529[2] | | 1,117 |
| Federal, regular | | 1,117 | |
| Federal, accelerated | | 0 | |
| Installation of practices (non-Federal) | | | 15,149 |
| *State & corporated management* | | 1,124 | |
| Land treatment | 107,075 | 1,969 | |
| Water management | 8,632 | 1,523 | |
| Urban drainage | 7,802 | 10,533 | |
| Total | | | 16,266 |
| **1980-2000** | | | |
| Technical assistance & management | 109,529[2] | | 1,624 |
| Federal, regular | | 1,553 | |
| Federal, accelerated | | 71 | |
| *Installation of practices (non-Federal)* | | | 16,788 |
| State & corporate management | | 1,498 | |
| Land treatment | 107,075 | *2,625 | |
| Water management | 10,550 | *2,566 | |
| Urban drainage | 7,481 | *10,099 | |
| Total | | | 18,412 |
| **2000-2020** | | | |
| Technical assistance & management | 109,529[2] | | 1,553 |
| Federal, regular | | 1,553 | |
| *Federal, accelerated* | | 0 | |
| Installation of practices (non-Federal) | | | 18,089 |
| State & corporate management | | 1,498 | |
| Land treatment | 107,075 | *2,625 | |
| Water management | 5,000 | *3,000 | |
| Urban drainage | 8,123 | *10,966 | |
| Total | | | 19,642 |

[1] Base: 1967 prices, except items asterisked which are adjusted normalized prices (See page 2-89 et seq.)

[2] Total acres in Islands involved in program measures.

# Snohomish Basin



# SNOHOMISH BASIN

The Snohomish Basin is located in southern Snohomish County and in northeastern King County. Approximately half of the Basin is located in each of the two counties.

The Snohomish is one of the larger rivers in the Puget Sound Area. It drains an area of 1,823 square miles. The principal tributaries are the Snoqualmie River, located in King County and draining an important agricultural area, and the Skykomish River, located mainly in southern Snohomish County. Coastal waters, which flow directly into Puget Sound, drain an area of 81 square miles.

# PRESENT STATUS

In 1963 the population was 178,200; and projections indicate that by 1980 the population will be 302,700; by 2000, 485,800; and by the year 2020 will reach 780,300. Population density at the present time, based on urban and rural non-farm lands, is 2.71 people per acre.

Forestry and farming remain the main users of land in the Basin. Although considerable quantities of vegetables and berries are produced in the region, approximately three-fourths of the cropland is used to support the livestock industry. Total value of farm production is over $12 million annually.

Forestry remains a major industry in the Basin and supports numerous mills, including several lumber mills, pulp mills, and paper manufacturing mills. Forested lands comprise approximately 1,055,000 acres, including associated open lands.

The manufacturing of paper products has been the principal industry, but transportation equipment will likely take first place. Other important industries include lumbering, farming, food processing, fishing and mining. Recreation, including hunting, fishing, camping, and skiing plays an ever increasing role in the economy of the Basin.

The Snohomish River and its tributaries support major runs of salmon that contribute significantly to the commercial and sport fisheries within the Puget Sound Area, Strait of Juan de Fuca, and the Pacific Ocean. The economy of the Area benefits from the fishery resource produced from the Snohomish Basin.

Many types of wildlife inhabit the Snohomish Basin. The Snohomish flood plain is an important waterfowl wintering area. One or more of the varied species of upland game inhabit virtually every habitat type. Fur-bearing animals are found along streams and near swampy areas. Big game is an important consideration in the wildlife inventory as a large part of the Basin is in some form of woodland cover.

Water-based recreation resources include about 50 miles of shoreline on Puget Sound, numerous lakes, rivers, and small streams. The eastern half of the Basin contains many attractive, small, high-elevation lakes. Other recreation attractions include the mountainous areas of the Cascade Range which contain about 104,000 acres of alpine and sub-alpine terrain and a large section of the Glacier Peak Wilderness Area. There are large winter sports developments at Stevens and Snoqualmie Passes.

The climate of the Basin is conducive to extremes of streamflows. Late fall and winter frequently produce damaging floodflows and conversely midsummer drought produces low flow conditions which are detrimental to fish and wildlife, recreation, and to sanitation within the streams. Potential for development of streams and rivers is limited in many respects unless low flows can be augmented to some degree by structural measures and management practices. Low flow characteristics for streams in the Basin are given in Appendix III, Hydrology.

Some unfavorable conditions of stream and river channels in the basin are partly the result of nearly a century of exploitation by man with only the last few years devoted to efforts to protect and rehabilitate the environment. Streambank erosion is severe during periods of high runoff in areas where sediment and debris reduce channel capacity.

Sediment is being dredged from the Everett harbor area. This sediment is largely the result of bedload movement during periods of high runoff. Small slides on several of the tributary streams contribute to the sediment being deposited.

A project on French Creek, Watershed Area number 8-2, has been completed and one at Marsh-

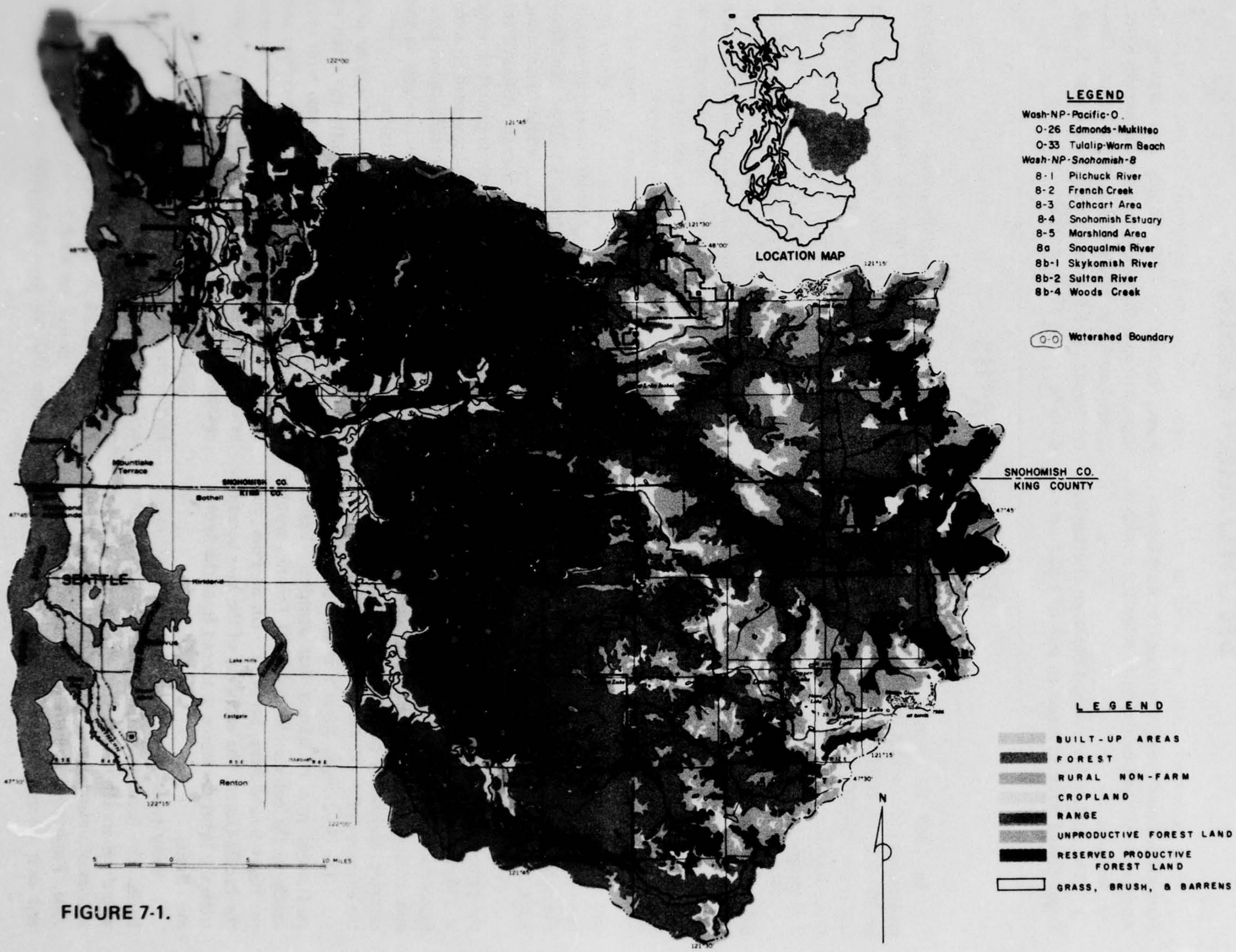



FIGURE 7-1.

SNOHOMISH BASIN
GENERALIZED LAND USE MAP

land, Watershed Area number 8-5, is underway. Both projects are largely for floodwater reduction and drainage control (see Figure 7-1).

## PRESENT LAND USE

The Snohomish Basin provides the third largest valley system in the Puget Sound Area. The system includes many flood and drainage problem areas which require corrective measures before their potential can be attained. The lower flood plain contains about 60,000 acres of level or gently undulating river bottom lands and tidelands. A large percentage of the Basin contains steep, mountainous valleys with turbulent streams. Below the juncture of the Snoqualmie and Skykomish Rivers, the valley drops almost to sea level and widens to a flat, fertile plain as much as 3 miles wide and 17 miles long (see Figure 7-1). The ownership distribution of the Basin's lands are shown on Figure 7-2

The broad categories of land use are given in Table 7-1. No attempt is made here to quantify multiple-use management of lands such as for game habitat, recreation, water quality, or low flow augmentation.

**TABLE 7-1. Present land use by sub-basin[1]**

| Land Use | Snohomish Basin (acres) | Coastal Waters (acres) | Total (acres) |
|---|---|---|---|
| Cropland | 71,077 | 675 | 71,752 |
| Rangeland | 2,379 | 45 | 2,424 |
| Forest[2] | 1,022,323 | 32,376 | 1,054,699 |
| Rural non-farm | 25,655 | 3,705 | 29,360 |
| Urban built-up | 22,233 | 14,122 | 36,355 |
| Fresh water | 22,716 | 1,145 | 23,861 |
| Total | 1,166,383 | 52,068 | 1,218,451 |

[1] Unadjusted measurements, 1966, for Puget Sound Area Study. Tabulations by ADP. First three figures are significant figures for acreages.

[2] Includes non-forested land normally associated with forest.

## SOILS

A medium intensity soil survey is available for most lands outside the national forest boundaries. Lands within the national forests were mapped from a reconnaissance-type survey.

The mapping units are discussed in the soil survey reports for Snohomish and King Counties and their locations are shown on maps. The soil survey report is available in libraries and in local offices of the United States Department of Agriculture.

The principal properties of each soil series are tabulated in Exhibit 1, Table 6 of this Appendix. Interpretations of data for each soil series are provided in subsequent tables of the Exhibit.

The total land area of 1,194,600 acres in the Snohomish Basin had a medium intensity survey on 660,800 acres and a low-intensity survey on 533,800 acres. Of the 660,800 acres, 379,000 acres are classified in Land Capability Classes II through VI, 276,700 acres are in Class VII, and 5,100 acres in Class VIII (Figure 7-3).

Lands in Land Use Capability Classes II through VI (287,500 acres) have the greatest potential for development: i.e., changed use or improved use. Land Use Capability Classes II, III, and IV may be suited for either crops or urban uses, and Class VI has potential for urban development. Most of the Class II and Class III lands in this Basin are subject to flooding and have wetness conditions which present hazards for many developed uses. Class VII is expected to be largely limited to forest use and Class VIII for recreation or aesthetic use.

The soil types in the Area having a medium intensity survey have been classified into land use capability classes and their primary and secondary subclasses, and capability units (see Exhibit 1, Tables 9 and 10). Lands having only reconnaissance surveys are roughly grouped into capability classes.

Tables 7-2 and 7-3 which follow give a tabulation of capability subclasses and specific wetness conditions for surveyed lands in this Basin.

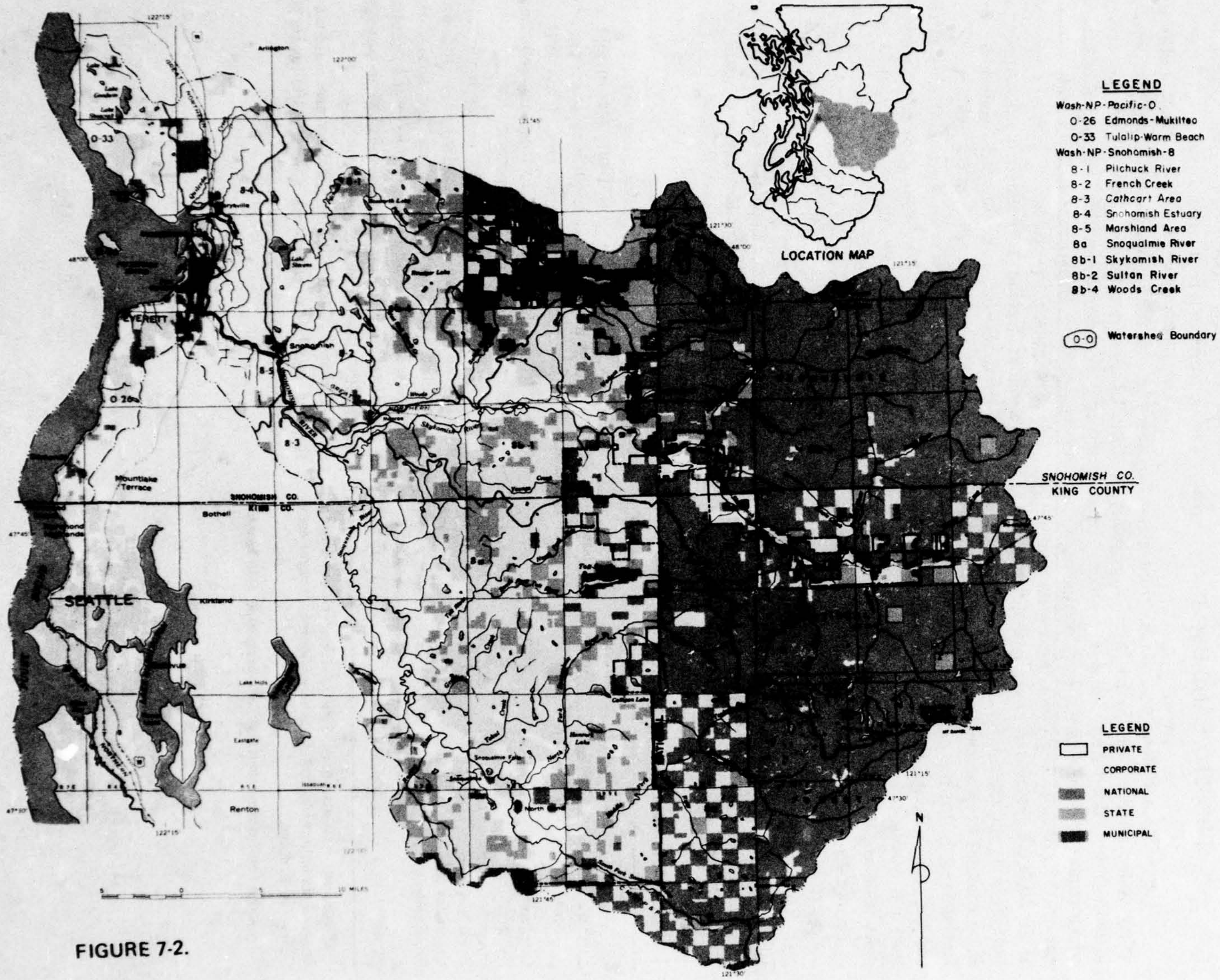



FIGURE 7-2.

SNOHOMISH BASIN
GENERALIZED OWNERSHIP MAP

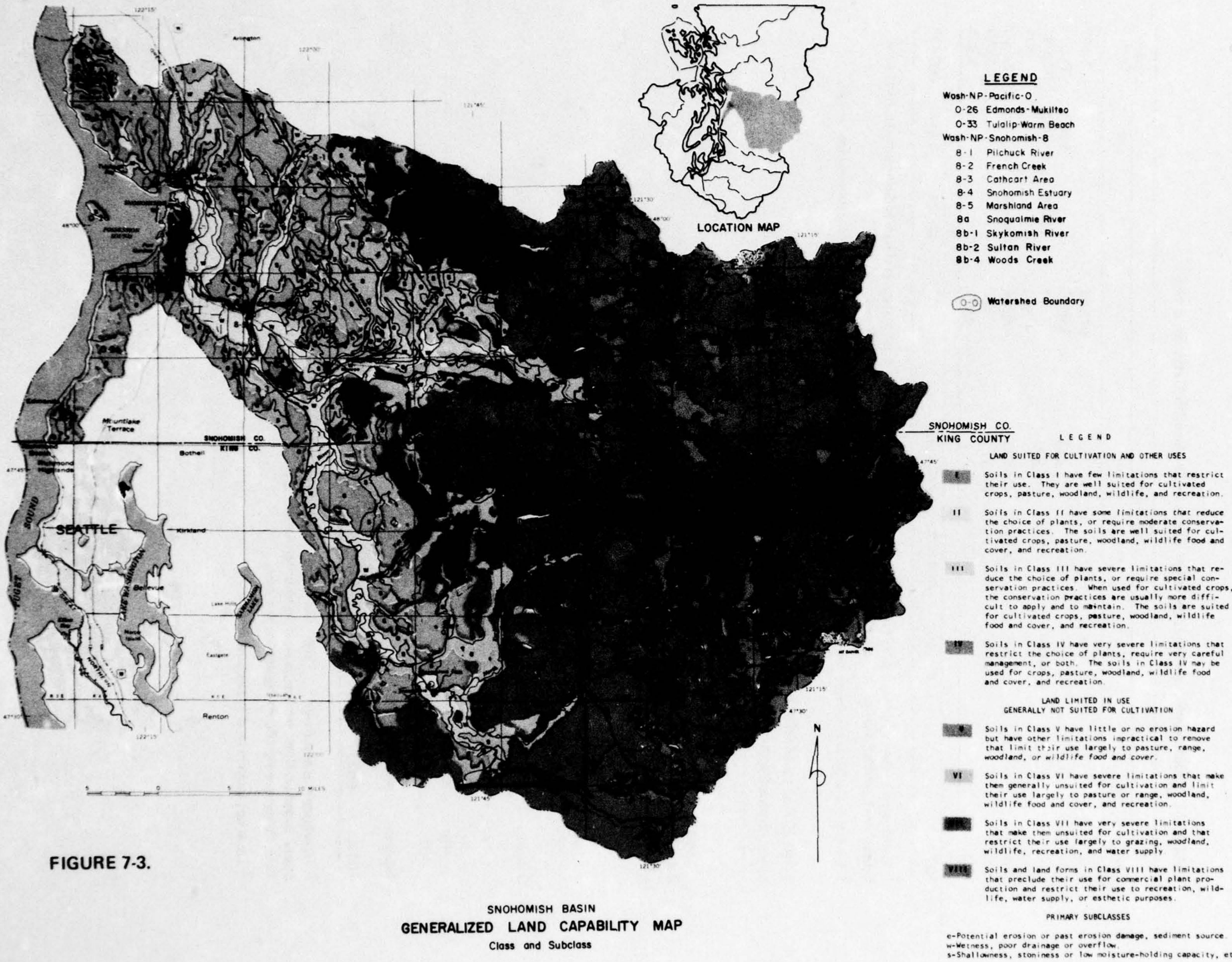



FIGURE 7-3.

SNOHOMISH BASIN
GENERALIZED LAND CAPABILITY MAP
Class and Subclass

**TABLE 7-2. Land conditions by capability classes in Snohomish Basin (in acres)[1]**

| Class | Subclasses[2] e | w | s | ew | es | we | ws | se | sw | Class Total |
|---|---|---|---|---|---|---|---|---|---|---|
| II | | | 286 | | | | 51,341 | | | 51,627 |
| III | | | 4,454 | 12,552 | 1,427 | | 26,990 | | 1,093 | 46,516 |
| IV | | | 16,689 | 125,415 | 4,946 | | 3,594 | 2,212 | 823 | 153,679 |
| V | | | | | | | 911 | | | 911 |
| VI | | | 33,045 | 26,566 | 21,589 | | 4,096 | 41,017 | | 126,313 |
| VII | | | 2,430 | | 273,721 | | 502 | | | 276,653 |
| VIII | | | 305 | 289 | | | 4,477 | | | 5,071 |
| TOTAL | | | 57,209 | 164,822 | 301,683 | | 91,911 | 43,229 | 1,916 | 660,770 |

[1] Unadjusted measurements, 1966, for Puget Sound Area Study, based on National Cooperative Soil Survey maps. First three figures are significant figures for acreages. Does not include land within national forests.

[2] Letters for subclasses denote hazards or conditions that affect land use and treatment: e—erosion; w—wetness: s—soil.

**TABLE 7-3. Land with wetness condition by capability classes Snohomish Basin (in acres)[1]**

| Land Capability Classes | All land in basin[2] Total All Land | All land in basin[2] With Wetness Conditions | Cropland in basin Total Cropland (est.) | Cropland in basin Cropland With Wetness Condition (est.) |
|---|---|---|---|---|
| II | 51,627 | 51,341 | 49,046 | 48,774 |
| III | 46,516 | 40,635 | 13,486 | 8,744 |
| IV | 153,679 | 129,832 | 9,220 | 5,789 |
| Subtotal | 251,822 | 221,808 | 71,752 | 63,307 |
| V | 911 | 911 | 0 | 0 |
| VI | 126,313 | 30,662 | 0 | 0 |
| VII | 276,653 | 502 | 0 | 0 |
| VIII | 5,071 | 4,766 | 0 | 0 |
| Subtotal | 408,948 | 36,841 | 0 | 0 |
| TOTAL | 660,770 | 258,649 | 71,752 | 63,307 |

[1] Unadjusted measurements, 1966, for Puget Sound Area Study, based on National Cooperative Soil Survey maps. First three figures are significant figures for acreages.

[2] Does not include land in national forests.

# PRESENT AND FUTURE NEEDS

## EVALUATION OF PRESENT SITUATION

During recent years there has been a very high rate of population immigration to the southwestern part of the Snohomish Basin. This immigration is expected to continue for some time. The bottom lands of the Basin are still largely in cropland and should remain as such. In the Snohomish Basin three broad categories of needs–protection from floodwater damage, measures for watershed protection and rehabilitation, and measures for water management–are present in varying degrees of intensity according to land use. About 71,752 acres are devoted to cropland use at the present time; 1,054,699 acres are in forest (including some areas of non-forested land); 2,424 acres are classed as rangeland; and 65,715 acres are in more intensive uses. According to Appendix VII, Irrigation, 12,800 acres were under irrigation in 1966.

## ESTIMATED FUTURE NEEDS

Determination of needs is made on the basis of multiple-use management and the categories of floodwater damage reduction. Watershed protection and rehabilitation measures, and water management contain the practices needed for development under the concept. Development needed in forestry and farming is to keep pace with other needs as the population increases and reach the level required by 2020.

Future needs are given in acres of land to be treated. Intensity or degree of practice application will increase with use. Management practices for enhancement of multiple-use objectives may require several practices on the same acre of land. A partial listing of practices used is given in Tables 2-18 and 2-19 in the Puget Sound Area section of this Appendix under Means to Satisfy Needs.

The projected rapid rise in population, with its requirements for space, recreation, and other land and water needs, makes it necessary to initiate an early action program of development to avoid costly misuse of the land resource. An obvious need in this Basin is for improved floodwater damage reduction on the Snohomish, Snoqualmie, and Skykomish River flood plains as described in Appendix XII, Flood Control, and for flood prevention and drainage facilities to be installed on two watersheds considered to be in need of improvements to accommodate orderly development of the Basin. Details of these early action projects are found in the Means to Satisfy Needs section.

Further urban development is expected in the lower portion of the Snohomish Basin. This development is expected to be on the bench terraces for the most part with only the estuarine area being developed for industrial use. The upper areas are expected

**TABLE 7-4. Future needs for watershed management [1]**

| Year | Floodwater Damage[2] Reduction[3] (acres) | Watershed Protection & Rehab.[3] (acres) | Drainage Improvement[3] (acres) | Irrigation Development[4] (acres) |
|---|---|---|---|---|
| Cropland | | | | |
| 1980 | 57,532 | 68,424[5] | 25,718 | 24,000 |
| 2000 | 57,532 | 66,424[5] | 42,863 | 30,000 |
| 2020 | 57,532 | 62,424 | 57,150[6] | 48,000 |
| Intensive Land Use | | | | |
| 1980 | 8,100 | 65,715 | 65,715 | 0 |
| 2000 | 8,100 | 80,967 | 80,967 | 0 |
| 2020 | 8,100 | 130,050 | 130,050 | 0 |
| Forested Land[7] | | | | |
| 1980 | 0 | 1,054,699 | 0 | 0 |
| 2000 | 0 | 1,047,199 | 0 | 0 |
| 2020 | 0 | 1,002,116 | 0 | 103,100[8] |
| Unclassified Land | | | | |
| 1980 | 0 | 5,752 | 0 | 0 |
| 2000 | 0 | 0 | 0 | 0 |
| 2020 | 0 | 0 | 0 | 0 |

1 Acreages derived by map measurements and ADP tabulation for the PS&AW study. Other potential not tabulated. Unrounded figures do not denote accuracy beyond the first three significant figures.

2 Includes overbank flooding of main streams.

3 Needed for full agricultural development (see Appendix V, Water-Related Land Resources, chapter 2, Agriculture.

4 According to Appendix VII, Irrigation, there were 12,800 acres (using 24,576 acres feet of water) irrigated in 1966. Irrigation Appendix projections show 14,800 acres irrigated by 1980, 18,700 acres by 2000, and 20,000 acres by 2020.

5 Includes 2,424 acres of rangeland.

6 Does not agree with Table 7-3 due to land use changes during time lapse.

7 Includes some non-forested land commonly associated with forests.

8 Potential irrigation of forests (see Appendix V, chapter 3, Forestry).

to remain in forest and the flood plains of the major streams in cropland use. The estimated number of acres, according to land use, that will require protective and development measures by the years 1980, 2000, and 2020 are tabulated in Table 7-4. The same land area may require more than one of these practices.

Table 7-5 shows drainage groups in the watersheds of the Snohomish Basin, with the acreage of land falling into each drainage group. From this and other data the drainage needs for expected land uses in the basin are derived.

**TABLE 7-5. Drainage groups in Snohomish Basin[1] (in acres)[2]**

| LINE | Watershed Area No.[3] | River Basins and Watersheds | 01 | 02 | 03 | 04 | 05 | 06 | 07 | 08 | 09 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Snohomish River | | | | | | | | | | | | | | | | | |
| 1 | 8a | Snoqualmie River | 12,277 | 0 | 3,591 | 1,234 | 0 | 4,501 | 35 | 10 | 93 | 0 | 49,567 | 1,027 | 0 | 409 | 0 | 8,540 | 81,284 |
| 2 | 8b-1 | Skykomish River | 7,911 | 0 | 439 | 25 | 0 | 4,248 | 0 | 110 | 0 | 0 | 2,781 | 135 | 0 | 10 | 0 | 1,543 | 17,202 |
| 3 | 8b-2 | Sultan River | 682 | 0 | 468 | 0 | 0 | 430 | 0 | 5 | 0 | 0 | 906 | 0 | 0 | 0 | 0 | 0 | 2,491 |
| 4 | 8b-4 | Woods Creek | 1,161 | 0 | 747 | 0 | 0 | 3,721 | 900 | 412 | 0 | 0 | 10,352 | 90 | 0 | 0 | 0 | 0 | 17,383 |
| 5 | 8-1 | Pilchuck River | 2,687 | 0 | 2,200 | 0 | 0 | 2,284 | 270 | 227 | 0 | 0 | 26,608 | 60 | 0 | 23 | 0 | 250 | 34,609 |
| 6 | 8-2 | French Creek | 2,925 | 0 | 2,221 | 1,018 | 0 | 870 | 40 | 172 | 0 | 0 | 3,353 | 70 | 0 | 318 | 0 | 35 | 11,022 |
| 7 | 8-3 | Cathcart Area | 1,266 | 0 | 140 | 0 | 0 | 488 | 0 | 55 | 0 | 0 | 3,249 | 20 | 0 | 0 | 0 | 106 | 5,323 |
| 8 | 8-4 | Snohomish Estuary | 6,316 | 0 | 3,099 | 2,942 | 0 | 4,682 | 0 | 4,951 | 0 | 0 | 16,713 | 127 | 0 | 95 | 0 | 583 | 39,508 |
| 9 | 8-5 | Marshland Area | 2,912 | 0 | 813 | 2,491 | 0 | 212 | 0 | 15 | 0 | 0 | 5,545 | 98 | 0 | 25 | 0 | 20 | 12,131 |
| | | Total | 38,137 | 0 | 13,718 | 7,710 | 0 | 21,436 | 1,245 | 5,957 | 93 | 0 | 119,074 | 1,627 | 0 | 880 | 0 | 11,076 | 220,953 |
| | | Puget Sound Drainages | | | | | | | | | | | | | | | | | |
| 11 | 0-26 | Edmonds-Mukilteo | 325 | 0 | 425 | 0 | 0 | 389 | 0 | 155 | 0 | 0 | 14,444 | 8 | 0 | 0 | 0 | 100 | 15,846 |
| 12 | 0-33 | Tulalip–Warm Beach | 742 | 0 | 979 | 0 | 0 | 560 | 0 | 327 | 0 | 0 | 19,156 | 0 | 0 | 0 | 0 | 0 | 21,764 |
| 13 | | Total | 1,067 | 0 | 1,404 | 0 | 0 | 949 | 0 | 482 | 0 | 0 | 33,600 | 8 | 0 | 0 | 0 | 100 | 37,610 |
| 14 | | Grand Total | 39,204 | 0 | 15,122 | 7,710 | 0 | 22,385 | 1,245 | 6,439 | 93 | 0 | 152,674 | 1,635 | 0 | 880 | 0 | 11,176 | 258,563 |

[1] Descriptions of drainage groups are found in the Means to Satisfy Needs section of the Area report.

[2] Unadjusted measurements, 1966, for Puget Sound Area Study. Tabulation by ADP. Read three significant figures.

[3] See Figure 7-1 for location.

# MEANS TO SATISFY NEEDS

Population forecasts predict about 780,300 people in the Snohomish Basin by 2020. The means used to accomplish the levels necessary to meet the needs of this expected population consist of programs and projects for protection and development of the land and water resources of this Basin. The wise use and development of these resources can supply the spatial needs and aesthetic wants required by a growing population. The needs as developed in other appendices have been considered in this appendix as related ot the land and water resources of the Basin.

The objectives of the plan for watershed management are to develop the Basin's resources to achieve its potential production of food and fiber as economically justified, to preserve and enhance fish, wildlife, and recreation values in accord with the Fish and Wildlife, and Recreation Appendices to provide for development of urban areas not subject to floodwater hazard, and to provide spatial needs in keeping with aesthetic qualities of the Area. These objectives will be carried out by various agencies of the Federal and State governments working in close cooperation with each other and with private sources.

## Land Use

Table 7-1 in Present Status indicates by subbasins the present land use. Table 7-6 summarizes by time periods the estimated future use of the land.

## Flooding

Floodwater damage must be prevented to the extent the hazard remaining does not materially exceed other risks before development becomes practical. Loss is limited to tolerable values by restricting developments on hazardous areas.

Watersheds require varied combinations and intensities of management according to the capability of the land and its use. Programs are planned to stabilize land and related water and thus benefit most functional uses of water. Special objectives for improvement may be selected for project purposes.

**TABLE 7-6. Estimated future land use**

| Year | Crop land (acres) | Range-land (acres) | Forest[1] (acres) | Urban Built-up[2] (acres) | Fresh water (acres) | Misc. uses[3] (acres) | Total (acres) |
|---|---|---|---|---|---|---|---|
| 1980 | 66,000 | 2,424 | 1,054,699 | 65,715 | 23,861 | 5,752 | 1,218,451 |
| 2000 | 64,000 | 2,424 | 1,047,199 | 80,967 | 23,861 | 0 | 1,218,451 |
| 2020 | 60,000 | 2,424 | 1,002,116 | 130,050 | 23,861 | 0 | 1,218,451 |

1 Includes non-forested land normally associated with forest.

2 Rural non-farm is assumed to be all urban by 1980. Built-up based on average urban density of six persons per acre.

3 Unspecified uses including land in transitional usage.

## PLAN OF DEVELOPMENT

This plan to provide for satisfaction of the needs as brought out in the Needs discussion will utilize the program and project approach, as explained in the Puget Sound Area section. The plan will guide the development of the resources of the Snohomish Basin to provide for spatial and production requirements for the expected population of its service area to the year 2020. The Snohomish Basin offers numerous opportunities for projects and programs that could maintain and increase fish and wildlife, and improve recreation areas.

### Early Action Projects

Several projects will be initiated prior to 1980 to remedy existing floodwater and drainage problems and to develop lands toward their potential for continued use. Table 7-7 describes projects in the early action plan:

**Patterson Creek Watershed Area 8a, Figure 7-1** is tributary to the Snoqualmie River downstream from Fall City. Its flood plain is narrow until it breaks out onto the flood plain of the Snoqualmie. Most of the flood plain has been cultivated and the hills on each side of the stream are heavily forested with second growth mixed stands of Douglas-fir and alder. Urban developments are beginning to appear scattered throughout the higher portions of the watershed. A good highway between Fall City and Redmond follows the Patterson Creek flood plain for most of its length.

The project is feasible for flood prevention on agricultural and urban areas, and drainage of agricultural lands. The area contains 12,451 acres of which 1,604 acres are cropland, 10,567 acres are forest, 255 acres rural non-farm and urban, and 25 acres miscellaneous uses.

The works of improvement will consist of 8 miles of improved and stabilized channel and one water control structure to stabilized the water table in organic soils.

**TABLE 7-7. Costs and benefited areas, early action projects recommended for installation by 1980.**

| Watershed Area No. and Name[1] | Project Area (acres | Project Structural Measures Cost[2] (dollars | Flood Water Protection (acres) | Drainage Improvement (acres) |
|---|---|---|---|---|
| 8a Patterson Cr.[3] | 12,451 | 392,000 | 667 | 1,426 |
| 8-4 Snohomish Estuary[3] | 25,759 | 2,111,000 | 12,321 | 10,222 |
| Total | 38,210 | 2,503,000 | 12,988 | 11,648 |

1 See Figure 7-1 for location.

2 1967 prices.

3 Part of the Snoqualmie River watershed.

Installation cost is estimated to be $392,125, of which the Federal share is $264,750, and the local share is $127,375. Benefits form damage reduction and drainage will provide a benefit-cost ratio of 1.5 to 1. To achieve benefits made possible by the structural works and other management during a 15-year period local interests will install necessary land treatment measures for erosion control and flood management, costing approximately $917,798, drainage measures estimated to cost $298,513, and forest protection and mangement practices costing $1,009,321 for a total of $2,225,632. The total cost of installing the structural measures and the land treatment measures is $2,617,757.

**Snohomish Estuary Watershed Area 8-4, Figure 7-1** is located north and east of Everett and on the Snohomish River downstream from the town of Snohomish. The flood plain of the Snohomish River and the low hills on each side are included in this watershed along with several islands in the river. The flood plain is nearly all farmed in grass for pasture while the higher portions are urbanized or in cutover brush forest. The forest area is limited to the few high ridges where young mixed stands of Douglas-fir and red alder occur. These areas should be planned for best landscaped appearance and minimizing of erosion as a result of land area development.

The project is designed for flood prevention of agricultural and urban areas, and drainage of agricultural lands. The area included in this watershed contains 25,759 acres of which 10,366 acres are cropland, 6,309 acres are forest, 8,392 acres rural non-farm and urban, and 692 acres miscellaneous uses.

The works of improvement will consist of 15 miles of improved and stabilized channel, three outlet structures consisting of floodgates and pumps, 13 improved floodgate structures, and 11 miles of new and reconstructed dike.

Installation cost is estimated to be $2,111,085, of which the Federal share is $1,616,765, and the local share is $494,320. Benefits from damage reduction and drainage will provide a benefit-cost ratio of 3.0 to 1. To achieve benefits made possible by the structural works and other management during a 15-year period local interest will install necessary land treatment measures for erosion control and flood management, cost approximately $774,030, drainage measures expected to cost $1,895,159, and forest protection and management practices costing $140,502 for a total of $2,779,691. The total cost of installing the structural measures and the land treatment measures is $4,890,776.

## Projects after 1980

Projects for the years 1980-2000, and 2000-2020 are shown in Table 7-8 with their expected costs. Benefits and benefit-cost ratios have not been computed for projects past 1980. Total installation costs will be $12,340,000.

**TABLE 7-8. Costs of projects recommended for installation after 1980.**

| Watershed Area No. and Name[1] | | Project Area (acres) | Structural Measures Installation Cost[2] (dollars) |
|---|---|---|---|
| 1980-2000 | | | |
| 8a | Snoqualmie River[3] | 424,360 | 2,280,000 |
| 8b-1 | Skykomish River | 426,616 | 720,000 |
| 8b-4 | Woods Creek | 40,880 | 500,000 |
| 8-1 | Pilchuck River | 78,454 | 1,000,000 |
| 8-3 | Cathcart Area | 8,897 | 600,000 |
| 8-4 | Snohomish Estuary[3] | 24,463 | 6,890,000 |
| 0-33 | Tulalip-Warm Beach | 26,437 | 250,000 |
| TOTAL | | 1,030,107 | 12,240,000 |
| 2000-2020 | | | |
| 8b-2 | Sultan River | 68,949 | 100,000 |
| TOTAL | | 68,949 | 100,000 |

[1] See Figure 7-1 for location.

[2] 1967 adjusted normalized prices.

[3] Portion of watershed to be completed prior to 1980.

## Programs

Program measures refer to on-farm and urban on-site practices which take advantage of improvements brought about by the structural works of improvement, as well as measures for watershed protection, erosion control, and water management. These measures will include seeding of improved grasses and legumes, cover crops, cropland and urban drainage development made possible by structural works of improvement, forest management practices, and irrigation development.

Tables 7-9 shows a breakdown of the various practices for each of the three time periods.

**TABLE 7-9. Watershed management practices for protection and development, by time periods, Snohomish Basin**

| Practice | Area (acres) | Cost[1] (thousands of dollars) | |
|---|---|---|---|
| First 15 Years | | | |
| Technical assistance & management | 1,128,875[2] | | 20,464 |
| Federal, regular | | 19,823 | |
| Federal, accelerated | | 641 | |
| Installation of practices (non-Federal) | | | 88,040 |
| State & corporate management | | 14,428 | |
| Land treatment | 599,442 | 7,096 | |
| Water management | 25,718 | 7,994 | |
| Urban drainage | 43,350 | 58,522 | |
| Total | | | 108,504 |
| 1980-2000 | | | |
| Technical assistance & management | 1,113,623[2] | | 42,705 |
| Federal, regular | | 41,209 | |
| Federal, accelerated | | 1,496 | |
| Installation of practices (non-Federal) | | | 91,522 |
| State & corporate management | | 19,238 | |
| Land treatment | 584,190 | *8,726 | |
| Water management | 17,145 | *5,036 | |
| Urban drainage | 43,350 | *58,522 | |
| Total | | | 134,227 |
| 2000-2020 | | | |
| Technical assistance & management | 1,064,540[2] | | 42,842 |
| Federal, regular | | 42,628 | |
| Federal, accelerated | | 214 | |
| Installation of practices (non-Federal) | | | 92,698 |
| State & corporate management | | 19,238 | |
| Land treatment | 535,107 | *8,141 | |
| Water management | 18,000 | *6,797 | |
| Urban drainage | 43,340 | *58,522 | |
| Total | | | 135,540 |

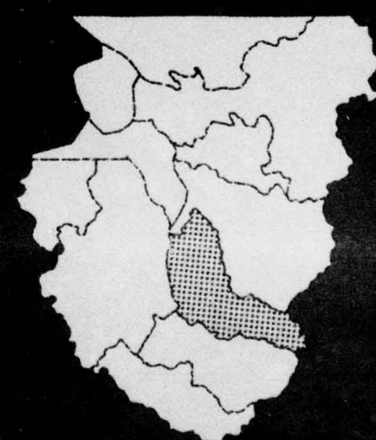
[1] Base: 1967 prices, except items asterisked which are 1967 adjusted normalized prices. See page 2-89 et. seq. for further explanation of costs.

[2] Total acres in Basin involved in program measures.

## Summary of Costs

Costs for the Snohomish Basin plan (projects costs plus program costs, rounded to the nearest thousand dollars) are expected to be $111,007,000 for the early action program: $146,467,000 for the years 1980-2000; and $135,640,000 for the years 2000 through 2020. Total cost of the plan will be $393,114,000. In addition to page 2-89, see page 2-95, Table 2-20, for further explanation of costs.

# Cedar-Green Basins



# CEDAR BASIN

The Cedar Basin is concentrated almost entirely in central King County, with approximately 12 percent of the Basin extending into southwestern Snohomish County. The Basin contains the Lake Washington and Sammamish River drainage areas.

The Cedar River flows into Lake Washington and drains an area of approximately 185 square miles and has no major tributaries.

The Sammamish River also empties into Lake Washington, and its principal tributaries, Swamp, Bear, and North Creeks drain approximately 238 square miles. Lake Washington empties into Shilshole Bay and drains approximately 164 square miles. Puget Sound drainage encompasses 33 square miles. The Cedar Basin as a whole drains about 620 square miles of territory.

# PRESENT STATUS

In 1963 the population was 776,500, and projections indicate that by 1980 the population will be 1,176,000; by 2000, it will be 1,889,400; and by the year 2020 will reach 3,035,200. The Seattle metropolitan complex is largely within the basin. Present density per acre, based on urban and rural non-farm lands, is 5.89 people per acre.

Farmlands in the Cedar and Sammamish River valleys are gradually being converted to residential and industrial use. The remaining cropland of approximately 20,000 acres is located largely on the rich alluvial lowlands. More than three-fourths of the cropland is used to support the livestock industry. Approximately 10 percent of the cropland is used for growing vegetables, berries, and nursery products. Total value of farm production is over $5 million annually.

Forestry at the present time remains the largest user of land in the Basin. It is one of the major industries in the region, and supports numerous mills and related industries.

The most important industry in the Basin has been, and should continue to be, its transportation equipment industry. Other important industries include clay products, foundries, timber and related forest products, farming, mining, fisheries, and various forms of manufacturing. Recreation, especially boating, swimming, water skiing, and sport fishing plays an important part in the economy of the Basin.

Salmon production from the Cedar Basin contributes significant quantities to the Puget Sound and ocean commercial and sport fisheries. The largest share of income and economic benefits derived from the Washington fishing industry is gained in the major seaport-water-front of the city of Seattle.

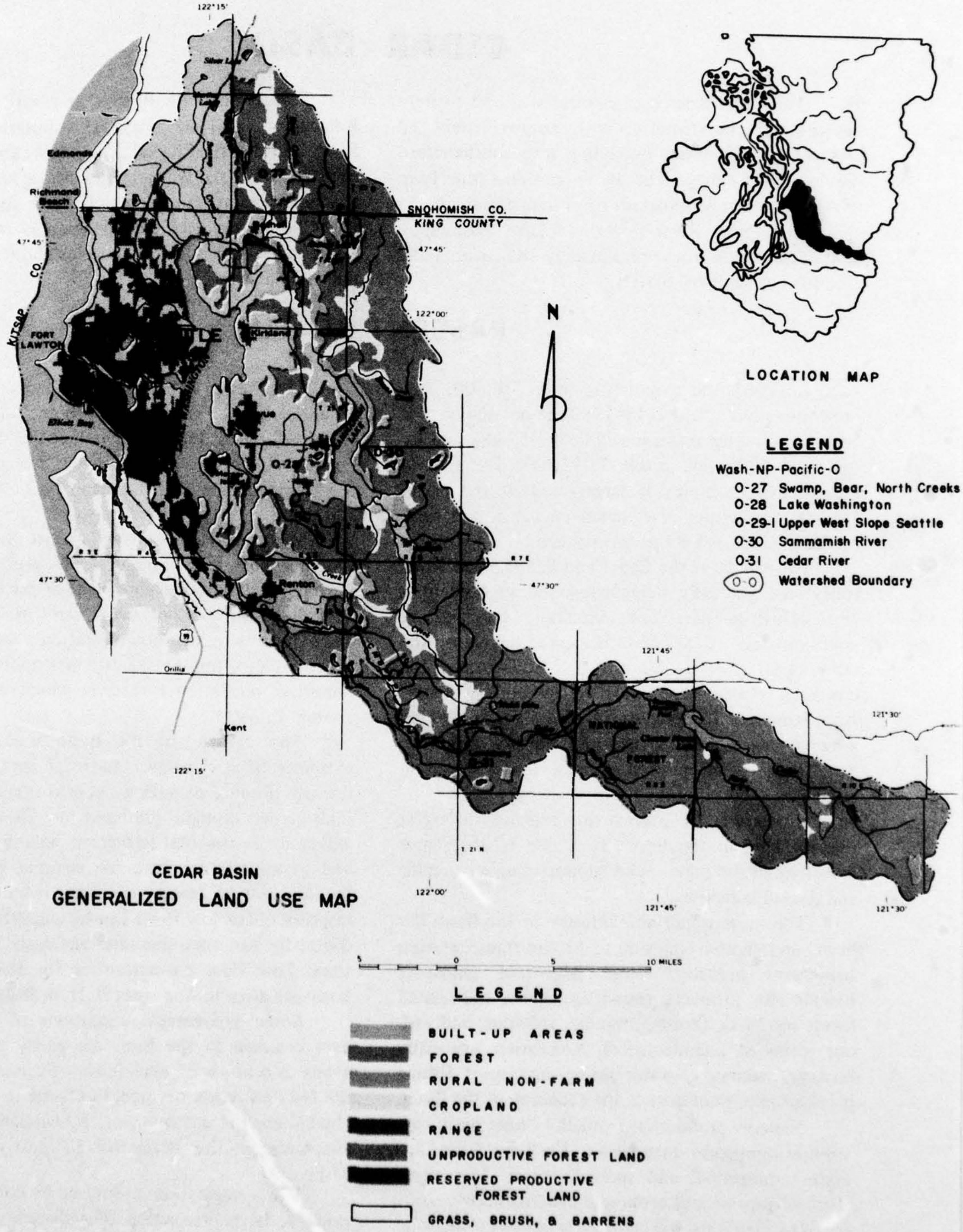
This area in its natural state had a high wildlife potential; however, extensively home and industrial site development has greatly reduced wildlife habitat. Where habitat is available various species of waterfowl, upland game, big game and fur-bearing animals still thrive.

Major recreation attractions are the water and shorelines of Puget Sound, Lake Washington, and Lake Sammamish. The shorelines of the Cedar River, as well as many other rivers, streams, and smaller lakes possess numerous recreation amenities. The urban parks within the Seattle metropolitan area are important recreation attractions which receive a large amount of use.

The climate of the Basin is conducive to extremes of streamflows. Late fall and winter frequently produce damaging floodflows and conversely midsummer drought produces low flow conditions which are detrimental to fish and wildlife, recreation, and to sanitation within the streams. Potential for development of streams and rivers is limited in many respects unless low flows can be augmented to some degree by structural measures and management practices. Low flow characteristics for streams in the Basin are given in Appendix II, Hydrology.

Some unfavorable conditions of stream and river channels in the Basin are partly the result of nearly a century of exploitation by man with only the last few years devoted to efforts to protect and rehabilitate the environment. Streambank erosion is less severe in this Basin than in most of the other basins.

Where vegetation is removed by construction or other activity production of sediment can become very great during periods of heavy rainfall.



CEDAR BASIN
GENERALIZED LAND USE MAP
SNOHOMISH CO.
KING COUNTY
KITSAP CO.
Edmonds
Richmond Beach
FORT LAWTON
Elliott Bay
Kirkland
Renton
Orillia
Kent
NATIONAL
FOREST
122° 15'
122° 00'
121° 45'
121° 30'
47° 45'
47° 30'
N
10 MILES
LOCATION MAP
LEGEND
Wash-NP-Pacific-O
0-27 Swamp, Bear, North Creeks
0-28 Lake Washington
0-29-I Upper West Slope Seattle
0-30 Sammamish River
0-31 Cedar River
0-0 Watershed Boundary
LEGEND
BUILT-UP AREAS
FOREST
RURAL NON-FARM
CROPLAND
RANGE
UNPRODUCTIVE FOREST LAND
RESERVED PRODUCTIVE FOREST LAND
GRASS, BRUSH, & BARRENS


FIGURE 8-1.

## PRESENT LAND USE

This Basin provides one of the smaller valley systems in the Puget Sound Area. The system includes many flood and drainage problem areas which require corrective measures before their potential can be attained. The lower flood plain contains about 16,000 acres of level or gently undulating bottom lands. The remainder of the land consists of gravelly terraces with some steep, mountainous valleys in the southeastern section of the Basin (see Figure 8-1). The ownership distribution of the Basin lands are shown on Figure 8-2.

The broad categories of land use are given in Table 8-1. No attempt is made here to quantify multiple-use management of lands such as for game habitat, recreation, water quality, or low flow augmentation.

**TABLE 8-1. Present land use by sub-basins[1]**

| Land Use | Sammamish River Basin (acres) | Cedar River Basin (acres) | Total (acres) |
|---|---|---|---|
| Cropland | 17,607 | 2,672 | 20,279 |
| Rangeland | 371 | 749 | 1,120 |
| Forest[2] | 106,500 | 104,141 | 210,641 |
| Rural non-farm | 21,292 | 4,087 | 25,379 |
| Urban built-up | 83,030 | 23,486 | 106,516 |
| Fresh water | 28,603 | 4,285 | 32,888 |
| Total | 257,403 | 139,420 | 396,823 |

[1] Unadjusted measurements, 1966, for Puget Sound study. Tabulations by ADP. First three figures are significant figures for acres.

[2] Includes non-forested land normally associated with forest.

## SOILS

A medium intensity soil survey is available for most lands outside the national forest boundary. Lands within the national forests were mapped from a reconnaissance-type survey. Parts of Seattle have been mapped with a high-intentisy soil survey.

The mapping units are discussed in the soil survey reports for King and Snohomish Counties and their locations are shown on maps. The soil survey report is available in libraries and in local offices of the United States Department of Agriculture.

The principal properties of each soil series are tabulated in Exhibit 1, Table 6 of this Appendix. Interpretations of data for each soil series are provided in subsequent tables of the exhibit.

The total land area of 364,000 acres in the Cedar Basin has a medium-intensity survey on 270,200 acres and a low-intensity survey on 93,800 acres. Of the 270,200 acres, 228,500 acres are classified in Land Capability Classes II through VI, 40,400 acres are in Class VII, and 1,200 acres in Class VIII (Figure 8-3).

Lands in the Land Use Capability Classes II through VI (228,500 acres) have the greatest potential for development; i.e., changed use or improved use. Land Use Capability Classes II, III, and IV may be suited for either crops or urban uses, and Class VI has potential for urban development. Most of the Class II and Class III lands in this basin are subject to flooding and have wetness conditions which present hazards for many developed uses. Class VII is expected to be largely limited to forest use and Class VII for recreation or aesthetic use.

The soil types in the Area having a medium intensity survey have been classified into land use capability classes and their primary and secondary subclasses, and capability units (see Exhibit 1, Tables 9 and 10). Lands having only reconnaissance surveys are roughly grouped into capability classes.

Tables 8-2 and 8-3 which follow give a tabulation of capability subclasses, and specific wetness conditions for surveyed lands in this basin.

AD-A037 582 PACIFIC NORTHWEST RIVER BASINS COMMISSION VANCOUVER WASH F/G 8/6
COMPREHENSIVE STUDY OF WATER AND RELATED LAND RESOURCES. PUGET --ETC(U)
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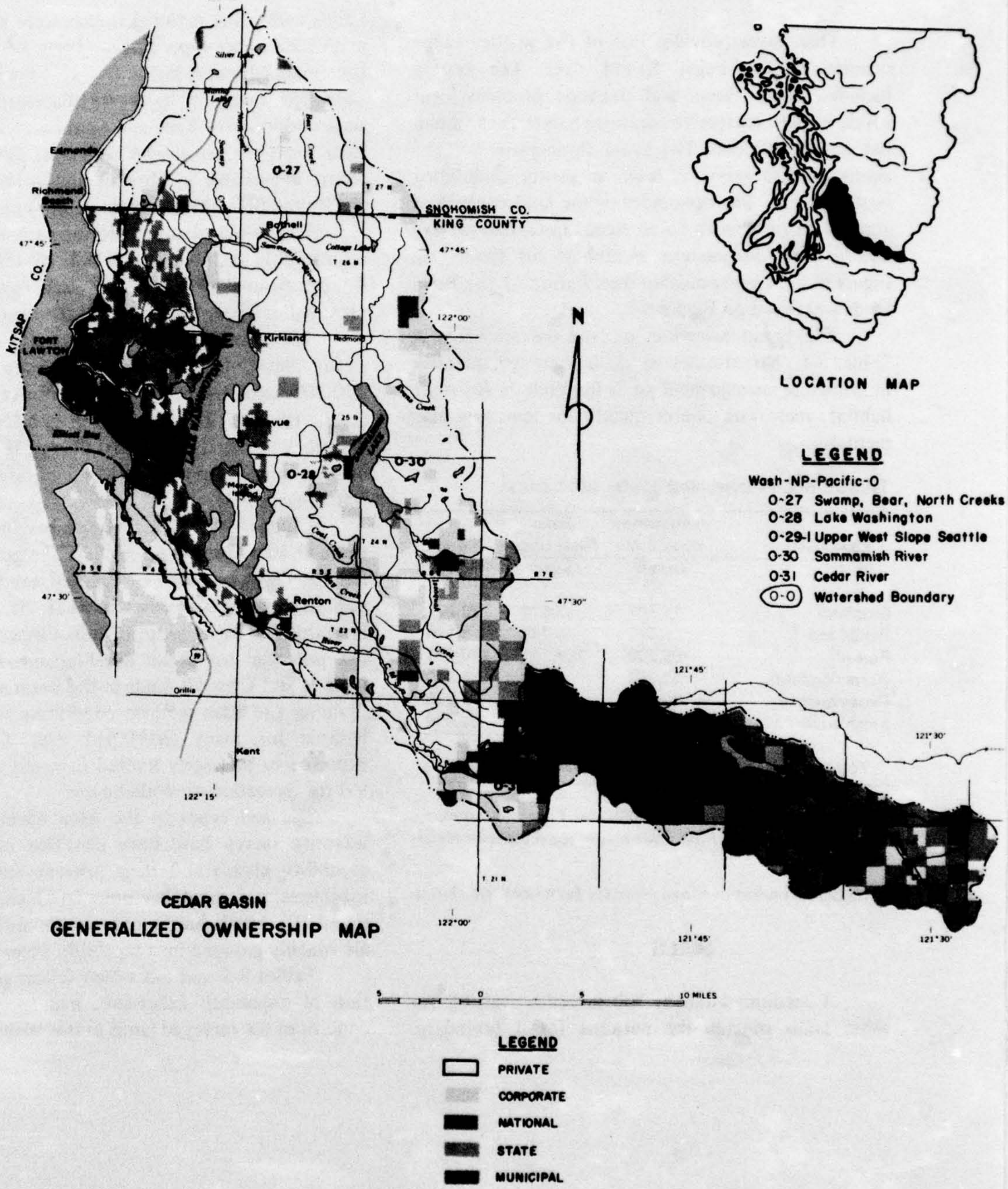
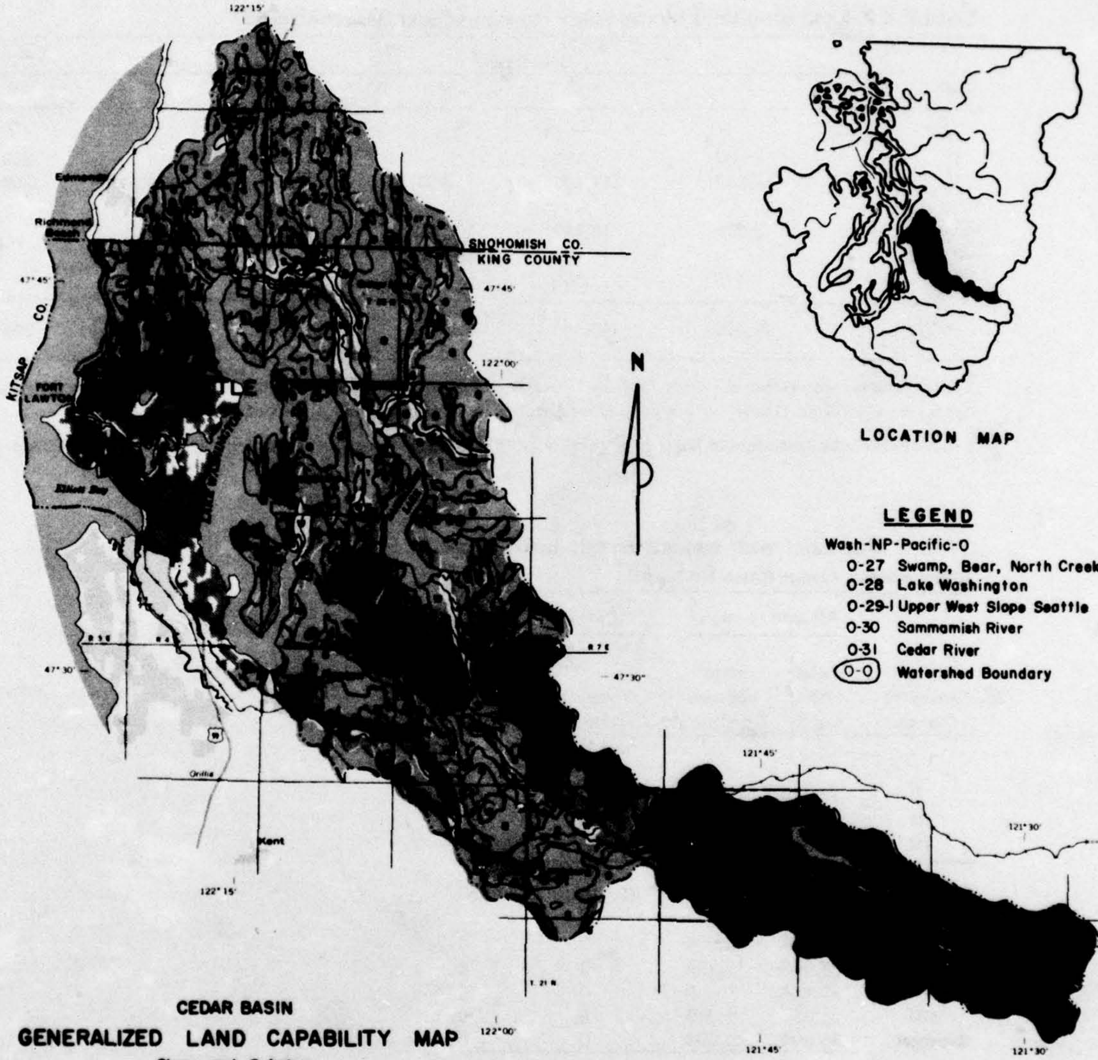

CEDAR BASIN
GENERALIZED OWNERSHIP MAP
SNOHOMISH CO.
KING COUNTY
KITSAP CO.
FORT LAWTON
Edmonds
Richmond Beach
Bothell
Kirkland
Redmond
Renton
Kent
Silver Lake
Cottage Lake
Elliott Bay
0-27
0-28
0-30
LOCATION MAP
LEGEND
Wash-NP-Pacific-O
0-27 Swamp, Bear, North Creeks
0-28 Lake Washington
0-29-I Upper West Slope Seattle
0-30 Sammamish River
0-31 Cedar River
0-0 Watershed Boundary
10 MILES
LEGEND
PRIVATE
CORPORATE
NATIONAL
STATE
MUNICIPAL

FIGURE 8-2.




CEDAR BASIN

## GENERALIZED LAND CAPABILITY MAP

Class and Subclass

LEGEND

**LAND SUITED FOR CULTIVATION AND OTHER USES**

Soils in Class I have few limitations that restrict their use. They are well suited for cultivated crops, pasture, woodland, wildlife, and recreation.

II — Soils in Class II have some limitations that reduce the choice of plants, or require moderate conservation practices. The soils are well suited for cultivated crops, pasture, woodland, wildlife food and cover, and recreation.

III — Soils in Class III have severe limitations that reduce the choice of plants, or require special conservation practices. When used for cultivated crops, the conservation practices are usually more difficult to apply and to maintain. The soils are suited for cultivated crops, pasture, woodland, wildlife food and cover, and recreation.

Soils in Class IV have very severe limitations that restrict the choice of plants, require very careful management, or both. The soils in Class IV may be used for crops, pasture, woodland, wildlife food and cover, and recreation.

**LAND LIMITED IN USE GENERALLY NOT SUITED FOR CULTIVATION**

Soils in Class V have little or no erosion hazard but have other limitations impractical to remove that limit their use largely to pasture, range, woodland, or wildlife food and cover.

Soils in Class VI have severe limitations that make them generally unsuited for cultivation and limit their use largely to pasture or range, woodland, wildlife food and cover, and recreation.

Soils in Class VII have very severe limitations that make them unsuited for cultivation and that restrict their use largely to grazing, woodland, wildlife, recreation, and water supply.

Soils and land forms in Class VIII have limitations that preclude their use for commercial plant production and restrict their use to recreation, wildlife, water supply, or esthetic purposes.

**PRIMARY SUBCLASSES**

e-Potential erosion or past erosion damage, sediment source.
w-Wetness, poor drainage or overflow.
s-Shallowness, stoniness or low moisture-holding capacity, etc.

**FIGURE 8-3.**

**TABLE 8-2. Land conditions by capability classes in Cedar Basin (in acres)[1]**

| Class | Subclasses[2] e | w | s | ew | es | we | ws | se | sw | Class Total |
|---|---|---|---|---|---|---|---|---|---|---|
| II | | | | | | | 13,815 | | | 13,815 |
| III | | | 30 | 7,159 | | | 6,652 | | 255 | 14,096 |
| IV | | | 16,907 | 117,705 | 1,903 | | 3,338 | 6,233 | 300 | 146,386 |
| V | | | | | | | 664 | | | 664 |
| VI | | | 8,275 | 18,112 | 10,930 | | 1,263 | 15,009 | | 53,589 |
| VII | | | | | 40,414 | | | | | 40,414 |
| VIII | | | 178 | 165 | | | 894 | | | 1,237 |
| TOTAL | | | 25,390 | 143,141 | 53,247 | | 26,626 | 21,242 | 555 | 270,201 |

[1] Unadjusted measurements, 1966, for Puget Sound Area Study, based on National Cooperative Soil Survey maps. First three figures are significant figures for acreages. Does not include land within national forests.

[2] Letters for subclasses denote hazards or conditions that affect land use and treatment: e—erosion; w—wetness: s—soil.

**TABLE 8-3. Land with wetness condition by capability classes, Cedar Basin (in acres)[1]**

| Land Capability Classes | All land in basin[2] Total All Land | With Wetness Condition | Cropland in basin Total Cropland (est.) | Cropland With Wetness Condition (est.) |
|---|---|---|---|---|
| II | 13,815 | 13,815 | 8,000 | 8,000 |
| III | 14,096 | 14,066 | 8,000 | 7,983 |
| IV | 146,386 | 121,343 | 4,279 | 3,547 |
| Subtotal | 174,297 | 149,224 | 20,279 | 19,530 |
| V | 664 | 664 | 0 | 0 |
| VI | 53,589 | 19,375 | 0 | 0 |
| VII | 40,414 | 0 | 0 | 0 |
| VIII | 1,237 | 1,059 | 0 | 0 |
| Subtotal | 95,904 | 21,098 | 0 | 0 |
| TOTAL | 270,201 | 170,322 | 20,279 | 19,530 |

[1] Unadjusted measurements, 1966, for Puget Sound Area Study based on National Cooperative Soil Survey maps. First three figures are significant figures for acres.

[2] Does not include land in national forests, or unsurveyed urban lands.

# PRESENT AND FUTURE NEEDS

## EVALUATION OF PRESENT SITUATION

In the Cedar Basin there has been a large influx of population during recent years. Most of this urban growth is taking place on the eastern side of Lake Washington from southern Snohomish County to Renton on the south. This rapid urbanization of previously forested area has increased sediment movement from the area manifold. Measures for management in three main categories—protection from floodwater damage, measures for watershed protection and rehabilitation, and measures for water management—are present in varying degrees of intensity according to land use. About 20,279 acres are now used as cropland; 210,641 acres are in forest (including some areas of non-forested land); 1,120 acres are classed as rangeland; and 131,895 acres are in more intensive uses. Appendix VII, Irrigation, indicates that 800 acres were under irrigation in 1966.

## ESTIMATED FUTURE NEEDS

Determination of needs is made on the basis of *multiple-use management and the categories of* floodwater damage reduction, watershed protection and rehabilitation measures, and water management contain the practices needed for development under the concept. Development needed in forestry and farming is to keep pace with other needs as the population increases and reach the level required by 2020.

Future needs are given in acres of land to be treated. Intensity of degree of practice application will increase with use. Management practices for enhancement of multiple-use objectives may require several practices on the same acre of land. A partial listing of practices used is given in Tables 2-18 and 2-19 in the Puget Sound Area section of this Appendix under Means to Satisfy Needs.

The projected rapid rise in population, with its requirements for space, recreation, and other land and water needs, makes it necessary to initiate an early action program of development to avoid costly misuse of the land resource. An obvious need in this Basin is for improved floodwater damage reduction on the Cedar River flood plain and to a lesser extent on the Sammamish River flood plain as described in Appendix XII, Flood Control, and for flood prevention and drainage facilities to be installed on two watersheds considered to be in need of improvements to accommodate orderly development of the Basin. Details of these early action projects are found in the Means to Satisfy Needs section.

The lower Cedar Basin is expected to become highly urbanized by 2020, with only a small number of farms remaining. Forest cover will be maintained on the upper watershed and managed for multiple uses. The estimated number of acres, according to land use, that will require protective and development measures by the years 1980, 2000, and 2020 are tabulated in Table 8-4. The same land area may require more than one of these practices.

**TABLE 8-4. Future needs for watershed management[1]**

| Year | Floodwater Damage[2] Reduction[3] (acres) | Watershed Protection & Rehab.[3] (acres) | Drainage Improvement[3] (acres) | Irrigation Development[3] ment[4] (acres) |
|---|---|---|---|---|
| Cropland | | | | |
| 1980 | 12,703 | 15,120[5] | 3,250 | 2,000 |
| 2000 | 12,703 | 13,120[5] | 5,417 | 3,000 |
| 2020 | 12,703 | 8,620[5] | 7,223[6] | 6,000 |
| Intensive Land Use[7] | | | | |
| 1980 | 8,600 | 196,000 | 196,000 | 0 |
| 2000 | 8,600 | 236,175 | 236,175 | 0 |
| 2020 | 8,600 | 303,520 | 303,520 | 0 |
| Forested Land[8] | | | | |
| 1980 | 0 | 152,815 | 0 | 0 |
| 2000 | 0 | 114,640 | 0 | 0 |
| 2020 | 0 | 51,795 | 0 | 20,358[9] |

1 Acreages derived by map measurements and ADP tabulation for the PS&AW study. Other potential not tabulated. Unrounded figures do not denote accuracy beyond the first three significant figures.

2 Includes overbank flooding of main streams.

3 Needed for full agricultural development (see Appendix V, Water—Related Land Resources, chapter 2, Agriculture).

4 According to Appendix VII, Irrigation, there were 800 acres (using 1,720 acre feet of water) irrigated in 1966. Irrigation Appendix projections show 400 acres will be irrigated by 1980; 0 acres by 2000; and 0 acres by 2020.

5 Includes 1,120 acres of rangeland.

6 Does not agree with Tables 8-3 due to land use changes during time lapse.

7 Calculated on basis of population density of 10.83 persons per acre for Cedar Basin. Other basins calculated on basis of 6 persons per acre.

8 Includes non-forested land commonly associated with forested areas.

9 Potential irrigation of forests (see Appendix V, chapter 3, Forestry).

Table 8-5 shows drainage groups in the watersheds of the Cedar Basin, with the acreage of land falling into each drainage group. From this and other data the drainage needs for expected land uses in the Basin are derived.

**TABLE 8-5. Drainage groups in Cedar Basin[1] (in acres)[2]**

| LINE | Watershed Area No[3] | River Basins and Watersheds | 01 | 02 | 03 | 04 | 05 | 06 | 07 | 08 | 09 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Cedar River | | | | | | | | | | | | | | | | | |
| 1 | 0-27 | Swamp, Bear, North Crs. | 478 | 0 | 1,802 | 207 | 0 | 2,741 | 0 | 407 | 0 | 0 | 29,109 | 825 | 0 | 105 | 0 | 25 | 35,699 |
| 2 | 0-28 | Lake Washington | 1,151 | 0 | 1,678 | 62 | 0 | 6,506 | 0 | 15 | 0 | 0 | 38,629 | 113 | 0 | 977 | 0 | 109 | 49,240 |
| 3 | 0-30 | Sammamish River | 3,812 | 0 | 2,572 | 130 | 0 | 6,903 | 0 | 0 | 312 | 0 | 43,169 | 178 | 0 | 845 | 0 | 1,037 | 58,958 |
| 4 | 0-31 | Cedar River | 1,276 | 0 | 692 | 12 | 0 | 867 | 0 | 0 | 0 | 0 | 17,507 | 282 | 0 | 110 | 0 | 1,246 | 21,992 |
| 5 | | Total | 6,717 | 0 | 6,744 | 411 | 0 | 17,017 | 0 | 422 | 312 | 0 | 128,414 | 1,398 | 0 | 2,037 | 0 | 2,417 | 165,889 |
| | | Puget Sound Drainages | | | | | | | | | | | | | | | | | |
| 6 | 0-29 | West Slope Seattle | 47 | 0 | 42 | 0 | 0 | 1,080 | 0 | 0 | 0 | 0 | 3,132 | 20 | 0 | 13 | 0 | 0 | 4,334 |
| 7 | | Total | 47 | 0 | 42 | 0 | 0 | 1,080 | 0 | 0 | 0 | 0 | 3,132 | 20 | 0 | 13 | 0 | 0 | 4,334 |
| 8 | | Grand Total | 6,764 | 0 | 6,786 | 411 | 0 | 18,097 | 0 | 422 | 312 | 0 | 131,546 | 1,418 | 0 | 2,050 | 0 | 2,417 | 170,223 |

[1] Descriptions of drainage groups are found in the Means to Satisfy Needs section of the Area report.

[2] Unadjusted measurements, 1966, for Puget Sound Area Study. Tabulations by ADP. Read three significant figures.

[3] See Figure 8–1 for location.

# MEANS TO SATISFY NEEDS

Projection indicate that by the year 2020 population in the Cedar Basin will be 3,035,200. The means used to reach the levels necessary to meet the needs of this expected population consist of programs and projects for protection and development of the land and water resources of the Basin. The wise use and development of these resources can supply the spatial needs and aesthetic wants of the growing population herein. The needs as developed in other appendices have been considered in this Appendix as related to the land and water resources of the Basin.

The objectives of the plan for watershed management are to develop the Basin's resources to achieve its potential production of food and fiber as economically justified, to preserve and enhance fish, wildlife, and recreation values in accord with the Fish and Wildlife, and Recreation Appendices, to provide for development of urban areas not subject to floodwater hazard, and to provide spatial needs in keeping with aesthetic qualities of the Area. These objectives will be carried out by various agencies of the Federal and State governments working in close cooperation with each other and with private sources.

### Land Use

Table 8-1 in Present Status indicates by subbasin the present land use. Table 8-6 summarizes by time periods the estimated future use of the land.

### Flooding

Floodwater damage must be prevented to the extent the hazard remaining does not materially exceed other risks before development becomes practical. Loss is limited to tolerable values by restricting development on hazardous areas.

Watersheds require varied combinations and intensities of management according to the capability of the land and its use. Programs are planned to stabilize land and related water and thus benefit most functional uses of water. Special objectives for improvement may be selected for project purposes.

## PLAN OF DEVELOPMENT

This plan to provide for the needs as brought out in the Needs discussion will utilize the program and project approach, as explained in the Puget Sound Area section. The plan will guide the development of the resources of the Cedar Basin to provide for spatial and associated requirements for the expected population of its service area to the year 2020. The Cedar River and several of its tributaries

**TABLE 8-6. Estimated future land use**

| Year | Crop-land (acres) | Range-land (acres) | Forest[1] (acres) | Urban Built-up (acres) | Fresh water (acres) | Total (acres) |
|---|---|---|---|---|---|---|
| 1980 | 14,000 | 1,120 | 152,815 | 196,000[2] | 32,888 | 396,823 |
| 2000 | 12,000 | 1,120 | 114,640 | 236,175[3] | 32,888 | 396,823 |
| 2020 | 7,500 | 1,120 | 51,795 | 303,520[4] | 32,888 | 396,823 |

1 Includes non-forested land normally associated with forest.

2 Rural non-farm is assumed to be all urban by 1980. Built-up based on average urban density of six persons per acre.

3 Figures at a density of eight people per acres.

4 Figured at a density of ten people per acre.

offer numerous opportunities for projects and programs that would maintain and increase fish and wildlife and improve recreational opportunities.

## Early Action Projects

Several projects will be initiated prior to 1980 to remedy existing floodwater and drainage problems and to develop lands toward their potential for continued use. Table 8-7 describes projects in he early action plan.

***Swamp, Bear and North Creeks Watershed Area* 0-27, Figure 8-1** discharges into the Sammamish River near Bothell. These streams flow toward the south and are nearly parallel. The topography is rolling hills most of which are under 500 feet in elevation. Urbanization is well along on Swamp Creek and is beginning to develop on North and Bear Creeks.

The watershed originally had a full forest cover. This is the area of earliest logging and repeated cutting and suburban development has reduced the original timber remaining to a few isolated tracts. Mixed stands of Douglas-fir and red alder are the principal species. Rapid urbanization now in progress is substantially reducing the area of forest land. Owners should be encouraged to create a tract of landscapes, and measures should be taken to preserve open areas for parks and playgrounds.

The project is designed for flood prevention of agricultural and urban areas, and drainage of agricultural lands. The area contains 44,795 acres of which 3,863 acres are cropland, 19,844 acres are forest, 21,008 acres rural non-farm and urban, and 80 acres miscellaneous uses.

The works of improvement will consist of 24 miles of improved and stabilized channel and two water control structures.

Installation cost is estimated to be $1,165,065, of which the Federal share is $815,520, and the local share is $349,545. Benefits from damage reduction and drainage will provide a benefit-cost ratio of 2.1 to 1. To achieve benefits made possible by the structural works and other management during a 15-year period

**TABLE 8-7. Costs and benefited areas, early action projects recommended for installation by 1980**

| Watershed Area No. and No.[1] | Project Area (acres) | Structural Measures Installation Cost[2] (dollars) | Flood-water Protec-tion (acres) | Drainage Improve-ment (acres) |
|---|---|---|---|---|
| 0-27 *Swamp, Bear, North Crs.* | 44,795 | 1,165,000 | 5,963 | 3,826 |
| 0-30 Evans Creek[3] | 28,800 | 1,015,000 | 3,348 | 3,620 |
| Total | 73,595 | 2,180,000 | 9,311 | 7,446 |

1 See Figure 8-1 for location.

2 1967 prices.

3 Part of the Sammamish River watershed.

local interest will install necessary land treatment measures for erosion control and flood management, costing approximately $277,268, drainage measures estimated to cost $939,276, and forest protection and management practices costing $421,883, for a total of $1,638,427. The total cost of installing the structural measures and the land treatment measures is $2,803,492.

**Evans Creek Watershed Area 0-30, Figure 8-1** outlets into the Sammamish River near Redmond. It drains a forested area of about 45 square miles located north and east of Redmond and Lake Sammamish. The topography of the area is rolling, with some hills approaching 600 feet in elevation. The outlet into the Sammamish River is approximately 30 feet mean sea level.

The flood plain near Redmond is broad and nearly level and in the upper reaches of the stream, the valley floor is relatively narrow and winding. Most of the cropland is located on the flood plain. Approximately two-thirds of the watershed is forested. Most of the area has been cut over several times and urbanization is progressing rapidly throughout the watershed. This trend is expected to continue as Seattle and adjoining areas are within easy commuting distance.

The project is designed for flood prevention of agricultural and urban areas, and drainage of agricultural lands. The area contains 28,800 acres of which 4,110 acres are cropland, 18,151 acres are forest, 6,448 acres rural non-farm and urban, and 91 acres miscellaneous uses.

The works of improvement will consist of 16 miles of improved and stabilized channel and two floodwater retarding structures for flood control and recreation.

Installation cost is estimated to be $1,014,895, of which the Federal share is $713,785, and the local share is $301,110. Benefits from damage reduction and drainage will provide a benefit-cost ratio of 1.9 to 1. To achieve benefits made possible by the structural works and other management during a 15-year period, local interests will install necessary land treatment measures for erosion control and flood management, costing approximately $294,998, drainage measures expected to cost $710,570, and forest protection and management practices costing $385,890 for a total of $1,391,458. The total cost of installing the structural measures and the land treatment measure is $2,406,353.

## Projects after 1980

Projects for the years 1980-2000 and 2000-2020 are shown in Table 8-8 with their expected costs. Benefits and benefit-cost ratios have not been computed for these projects. Total installation costs are anticipated to be $6,090,000. installing the structural measures and the land treatment measures is $3,910,000.

***TABLE 8-8. Costs of projects recommended for installation after 1980***

| Watershed Area No. and Name[1] | Project Area (acres) | Struc. Meas. Installation Cost[2] (dollars) |
|---|---|---|
| 1980-2000 | | |
| 0-28 Lake Washington | 82,496 | 520,000 |
| 0-30 Sammamish River[3] | 101,509 | 2,710,000 |
| 0-31 Cedar River | 114,743 | 580,000 |
| Total | 298,748 | 3,810,000 |
| 2000-2020 | | |
| 0-29 Upper West Slope Seattle | 37,256 | 100,000 |
| Total | 37,256 | 100,000 |

[1] See Figure 8-1 for location.

[2] 1967 prices

[3] Portion of the watershed to be completed after 1980.

## Programs

Program measures refer to on-farm and urban on-site practices which take advantage of improvements made possible by the structural works of improvement, as well as measures of watershed protection, erosion control, and water management. These measures will include seeding of improved grasses and legumes, cover crops, cropland and urban drainage development made possible by structural works of improvement, forest management practices, and irrigation development.

Table 8-9 shows a breakdown of the various practices for each of the three time periods.

## Summary of Costs

Costs for the Cedar Basin plan (projects costs plus program costs, rounded to the nearest thousand dollars) are expected to be $153,316,000 for the early action program; $ 155,135,000 for the years 1980-2000; and $151,012,000 for the years 2000 through 2020. Total cost of the plan will be $459,463,000. See page 2-89 et seq.; also page 2-95, Table 2-20, for further information on costs.

TABLE 8-9. Watershed management practices for protection and development, by time periods, Cedar Basin

| Practice | Area (acres) | Cost[1] (thousands of dollars) | |
|---|---|---|---|
| First 15 Years | | | |
| Technical assistance & management | 167,935[2] | | 5,775 |
| Federal, regular | | 4,446 | |
| Federal, accelerated | | 1,329 | |
| Installation of practices (non-Federal) | | | 145,361 |
| *State & corporate management* | | 3,763 | |
| Land treatment | 101,537 | 1,352 | |
| Water management | 3,250 | 930 | |
| Urban drainage | 103,197 | 139,316 | |
| Total | | | 151,136 |
| 1980-2000 | | | |
| Technical assistance & management | 127,760[2] | | 8,996 |
| Federal, regular | | 7,667 | |
| Federal, accelerated | | 1,329 | |
| Installation of practices (non-Federal) | | | 142,329 |
| State & corporate management | | 5,018 | |
| Land treatment | 61,362 | * 1,432 | |
| Water management | 2,167 | * 660 | |
| Urban drainge | 100,162 | *135,219 | |
| Total | | | 151,325 |
| 2000-2020 | | | |
| Technical assistance & management | 65,278[2] | | 8,104 |
| *Federal, regular* | | 7,661 | |
| Federal, accelerated | | 443 | |
| Installation of practices (non-Federal) | | | 142,808 |
| State & corporate management | | 5,018 | |
| Land treatment | 7,500 | * 900 | |
| Water management | 1,806 | * 1,671 | |
| Urban drainage | 100,162 | *135,219 | |
| Total | | | 150,912 |

1 Base: 1967 prices, except items asterisked which are adjusted normalized prices. See page 2-89 et. seq. for further explanation of costs.

2 Total acres in basin involved in program measures.

# GREEN BASIN

The Green Basin is located almost entirely in southern King County, with less than 1 percent of the Basin overlapping into northwestern Pierce County.

The Green River is one of the smaller rivers in the Puget Sound Area. It drains an area of 541 square miles. The principal tributaries are Soos Creek, Newaukum Creek, Coal Creek, and Black River.

# PRESENT STATUS

In 1963 the population was 200,200, and the projections indicate that by 1980 the population will be 303,000; by 2000, 486,300; and by the year 2020 will reach 781,100. Part of the city of Seattle is in the Green Basin. Population density at the present time, based on urban and rural non-farm lands, is 2.91 people per acre.

Land usage in the Green Basin is in a transitional stage from agriculture to industrial-commercial. The remaining cropland of 33,000 acres is located partly on the rich alluvial lowlands. More than three-fourths of the cropland is used to support the livestock industry. Approximately 10 percent of the cropland is used for growing vegetables, berries, and nursery products. Total value of farm production is over $8 million annually.

Forestry, although the largest user of land, has declined to a relatively unimportant status in the Basin. There are no large sawmills or woodpulp producing mills now located in the area.

As in the Cedar Basin, the manufacturing of transportation equipment is by far the most important industry in the Basin. A high level of activity is also noted in shipbuilding, machinery, primary metals, and fabricated metal manufacturing. Farming, mining, fisheries, and to a lesser extent, forestry, are also important industries within the Basin.

The Green River supports major salmon populations that contribute heavily to the commercial and sport fisheries of Puget Sound, the straits, and ocean coastal areas. Since Seattle is the major seaport of Puget Sound this area receives the largest portion of economic benefits from the fisheries resources.

This area in its natural state had a high wildlife potential. However, extensive home and industrial site development has greatly reduced wildlife habitat. Where habitat is available various species of waterfowl, upland game, big game, and fur-bearing animals still thrive.

The major recreation attraction is the water and shoreline of the Puget Sound. The shorelines of the Green River, as well as other streams and small lakes, possess numerous recreation amenities. A 12-mile section of the Green River Gorge from the town of Kanasket to the Kummer Bridge is unique.

The climate of the Basin is conducive to extremes of streamflows. Late fall and winter frequently produce damaging floodflows and conversely midsummer drought produces low flow conditions which are detrimental to fish and wildlife, recreation, and to sanitation within the streams. Potential for development of streams and rivers is limited in many respects unless low flows can be augmented to some degree by structural measures and management practices. Low flow characteristics for streams in the Basin are given in Appendix III, Hydrology.

The present condition of many stream and river channels in this Basin is partly the result of nearly a century of exploitation by man with only the last few years devoted to efforts to protect and rehabilitate the environment. Streambank erosion is severe in certain areas where sediment and debris reduce channel capacity.

Dredging operations at the mouth of the Green-Duwamish Rivers are needed to keep the harbor open to deep draft vessels. Sediment production is heavy during winter high flows. Bank erosion is moderate to severe below the Green River Gorge and is the source of considerable coarse sediments.

In the Basin projects are authorized for installation on East Side Green River and West Side Green River Watershed Area 0-34 and 0-35, respectively. These two projects are basically for floodwater reduction and drainage control (see Figure 8a-1).

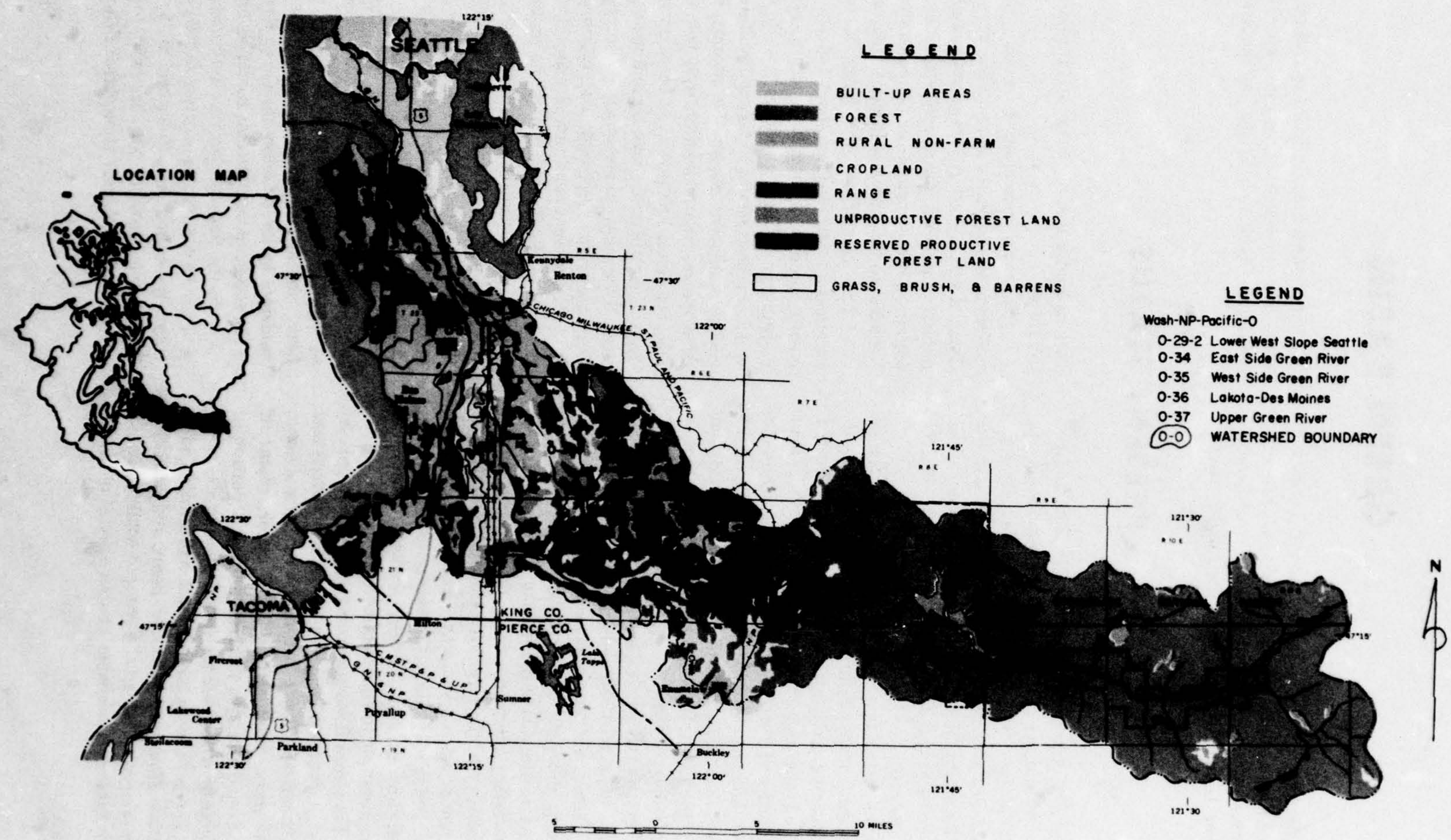



FIGURE 8a-1.

GREEN BASIN
GENERALIZED LAND USE MAP

## PRESENT LAND USE

The system includes many flood and drainage problem areas which require corrective measures before their potential can be attained. The lower flood plain contains about 17,000 acres of level or gently undulating bottom lands. Another acreage of the problem area is in the Osceola plateau. The undeveloped lands start at the foothills and graduate into sizable areas of steep, mountainous valleys in the eastern section of the Basin (see Figure 8a-1). The ownership distribution of the Basin lands are shown on Figure 8a-2.

The broad categories of land use are given in Table 8a-1. No attempt is made here to quantify multiple-use management of lands such as for game habitat, recreation, water quality, or low flow augmentation.

**TABLE 8a-1. Present land use by sub-basins [1]**

| Land Use | Green River Basin (acres) | Coastal Waters (acres) | Total (acres) |
|---|---|---|---|
| Cropland | 32,972 | 131 | 33,103 |
| Rangeland | 2,202 | 30 | 2,232 |
| Forest[2] | 230,165 | 5,882 | 236,047 |
| Rural non-farm | 8,017 | 949 | 8,966 |
| Urban built-up | 34,275 | 25,610 | 59,885 |
| Fresh water | 5,846 | 104 | 5,950 |
| Total | 313,477 | 32,706 | 346,183 |

[1] Unadjusted measurements, 1966, for Puget Sound Area Study. Tabulations by ADP. First three figures are significant figures for acreages.

[2] Includes non-forested land normally associated with forest.

## SOILS

A medium-intensity soil survey is available for most lands outside the national forest boundaries. Lands within the national forests were mapped from a reconnaissance-type survey. Parts of Seattle have been mapped by a high-intensity soil survey.

The mapping units are discussed in the soil survey reports for King and Pierce Counties and their locations are shown on maps. The soil survey report is available in libraries and in local offices of the United States Department of Agriculture.

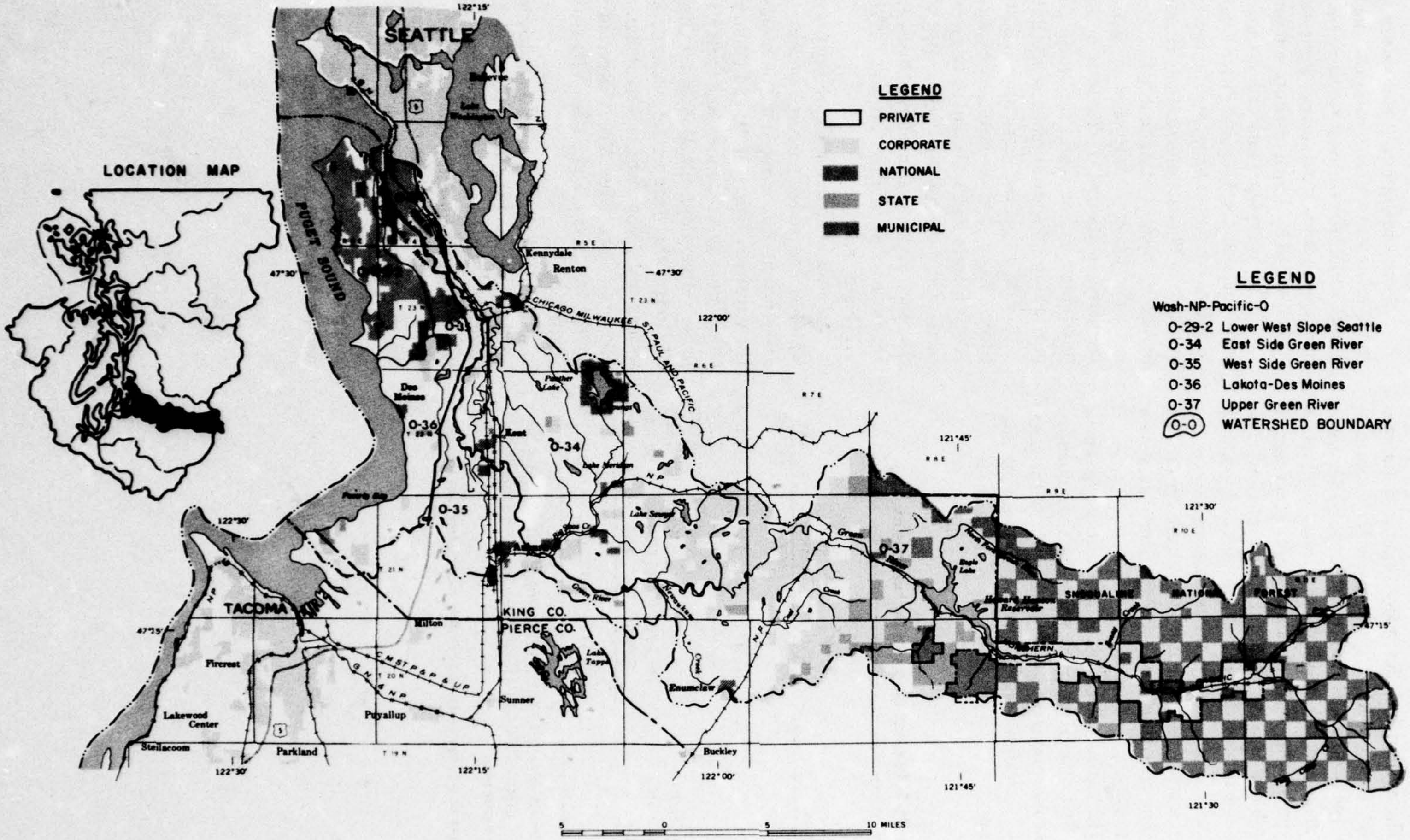
The principal properties of each soil series are tabulated in Exhibit 1, Table 6 of this Appendix. Interpretations of data for each soil series are provided in subsequent tables of the Exhibit.

The total land area of 340,200 acres in the Green Basin has a medium-intensity survey on 208,700 acres and a low-intensity survey on 131,500 acres. Of the 208,700 acres, 148,900 acres are classified in Land Capability Classes II through VI, 58,600 acres are in Class VII, and 1,200 acres in Class VII (Figure 8a-3).

Lands in Land Use Capability Classes II through VI (148,900 acres) have the greatest potential for development; i.e., changed use or improved use. Land Use Capability Classes II, III and IV may be suited for either crops or urban uses, and Class VI has potential for urban development. Most of the Class II and Class III lands in this Basin are subject to flooding and have wetness conditions which present hazards for many developed uses. Class VII is expected to be largely limited to forest use and Class VIII fro recreation or aesthetic use.

The soil types in the Area having a medium-intensity survey have been classified into land use capability classes and their primary and secondary subclasses, and capability units (see Exhibit 1, Tables 9 and 10). Lands having only reconnaissance surveys are roughly grouped into capability classes.

Tables 8a-2 and 8a-3 which follow give a tabulation of capability subclasses and specific wetness conditions for surveyed lands in this Basin.




GREEN BASIN

GENERALIZED OWNERSHIP MAP

FIGURE 8a-2.

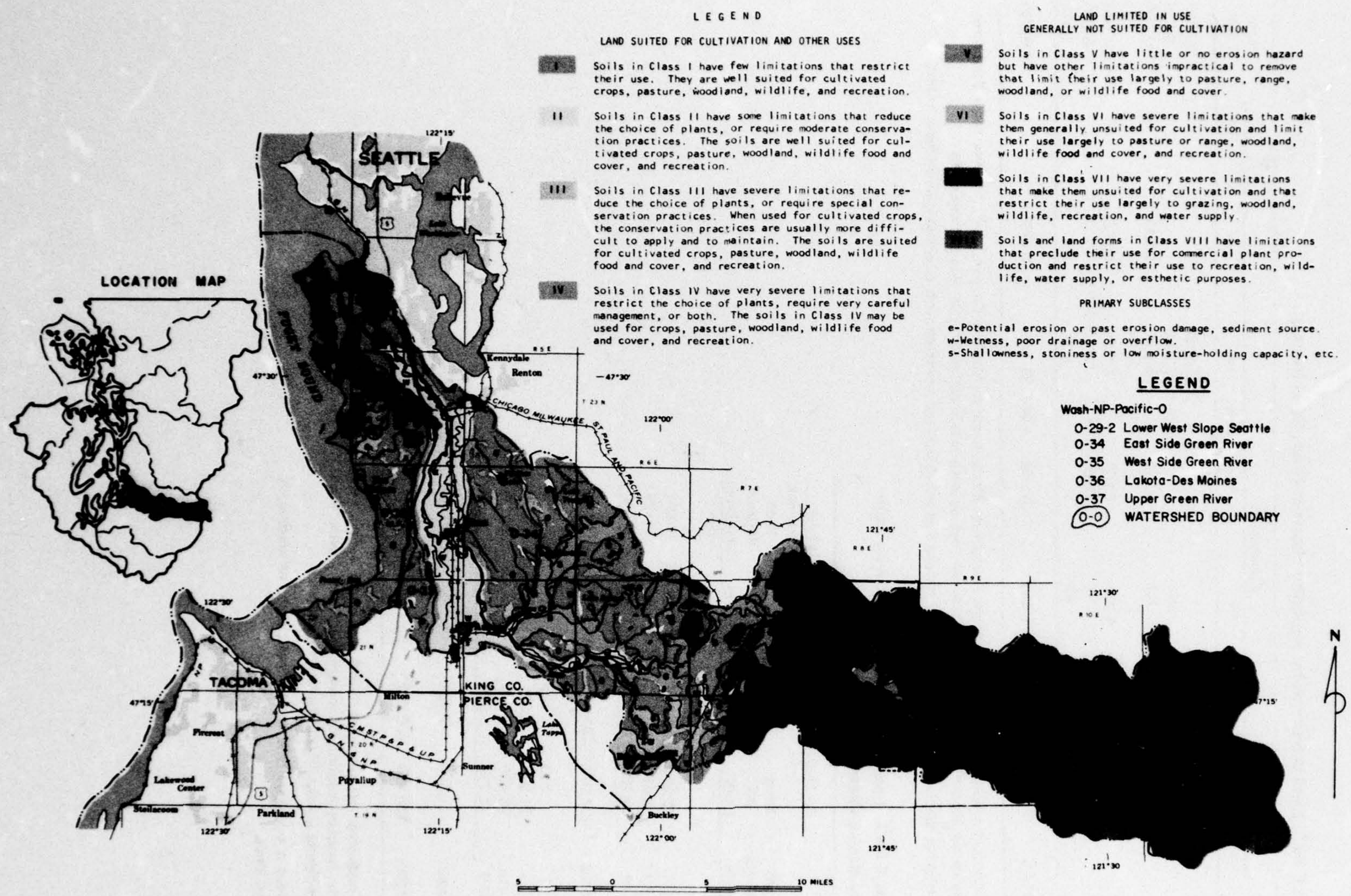



FIGURE 8a-3.

GREEN BASIN
GENERALIZED LAND CAPABILITY MAP
Class and Subclass

TABLE 8a-2. Land conditions by capability classes in Green Basin (in acres)[1]

| Class | e | w | s | ew | es | we | ws | se | sw | Class Total |
|---|---|---|---|---|---|---|---|---|---|---|
| | Subclasses[2] | | | | | | | | | |
| II | | | | | | | 25,208 | | | 25,208 |
| III | | | | 591 | | 1,961 | 6,124 | | | 8,676 |
| IV | | | 17,996 | 66,421 | 5,219 | | 1,159 | 2,391 | | 93,186 |
| V | | | | | | | 230 | | | 230 |
| VI | | | 5,587 | 4,774 | 3,611 | | 1,157 | 6,456 | | 21,585 |
| VII | | | | | 58,600 | | | | | 58,600 |
| VIII | | | 288 | 87 | | | 839 | | | 1,214 |
| TOTAL | | | 23,871 | 71,873 | 67,430 | 1,961 | 34,717 | 8,847 | | 208,699 |

[1] Unadjusted measurements, 1966, for Puget Sound Area Study, based on National Cooperative Soil Survey maps. First three figures are significant figures for acreages. Does not include lands within national forests and national parks.

[2] Letters for subclasses denote hazards or conditions that affect land use and treatment: e—erosion; w—wetness; s—soil.

TABLE 8a-3. Land with wetness condition by capability classes, Green Basin (in acres)[1]

| Land Capability Classes | All land in basin[2]: Total All Land | All land in basin[2]: With Wetness Condition | Cropland in basin: Total Cropland (est.) | Cropland in basin: Cropland With Wetness Condition (est.) |
|---|---|---|---|---|
| II | 25,208 | 25,208 | 21,427 | 21,427 |
| III | 8,676 | 8,676 | 5,126 | 5,126 |
| IV | 93,186 | 67,580 | 6,550 | 4,750 |
| Subtotal | 127,070 | 101,464 | 33,103 | 31,303 |
| V | 230 | 230 | 0 | 0 |
| VI | 21,585 | 5,931 | 0 | 0 |
| VII | 58,600 | 0 | 0 | 0 |
| VIII | 1,214 | 926 | 0 | 0 |
| Subtotal | 81,629 | 7,087 | 0 | 0 |
| TOTAL | 208,699 | 108,551 | 33,103 | 31,303 |

[1] Unadjusted measurements, 1966, for Puget Sound Area Study, based on National Cooperative Soil Survey maps. First three figures are significant figures for acreages.

[2] Does not include land in national forests, or unsurveyed urban lands.

# PRESENT AND FUTURE NEEDS

## EVALUATION OF PRESENT SITUATION

Due to existing transportation routes the lower part of the Green Basin is developing into an industrial area. The supporting residential and commercial areas are developing on bench terraces or plateau lands.

Measures for floodwater damage reduction, watershed protection and rehabilitation, and water management are present in varying degrees of intensity according to land use. About 33,103 acres are presently used as cropland, 236,047 acres are in forest (including non-forested areas), 2,232 acres are classified as rangeland, and 68,851 acres are in more intensive uses. Appendix VII, Irrigation, states that 1,800 acres were under irrigation in 1966.

## ESTIMATED FUTURE NEEDS

Determination of needs is made on the basis of multiple-use management and the categories of floodwater damage reduction. Watershed protection and rehabilitation measures, and water management contain the practices needed for development under the concept. Development needed in forestry and farming is to keep pace with other needs as the population increases and reach the level required by 2020.

Future needs are given in acres of land to be treated. Intensity or degree of practice application will increase with use. Management practices for enhancement of multiple-use objectives may require several practices on the same acre of land. A partial listing of practices used is given in Tables 2-18 and 2-19 in the Puget Sound Area section of this Appendix under Means to Satisfy Needs.

Flood control is provided by Howard A. Hanson storage and existing levees on the lower valley. The flood control measures in place, as well as authorized flood prevention and drainage projects on lower tributaries, will largely meet the needs for this protection through 1980. Continued development of watershed lands will necessitate additional projects in later years. A summation of these watershed management projects can be found in Means to Satisfy Needs portion of this Basin.

Some cropland is expected to remain in the Green Basin in 2020; however, some areas of land now in forest or crops will be developed for urban use. The estimated number of acres, according to land use, that will require protective and development measures by the years 1980, 2000, and 2020 are tabulated in Table 8a-4. The same land may require more than one of these practices.

**TABLE 8a-4. Future needs for watershed management**

| Year | Floodwater Damage[2] Reduction[3] (acres) | Watershed Protection & Rehab.[3] (acres) | Drainage Improvement[3] (acres) | Irrigation Development[4] (acres) |
|---|---|---|---|---|
| Cropland | | | | |
| 1980 | 17,910 | 27,232[5] | 7,447 | 5,000 |
| 2000 | 17,910 | 24,732[5] | 12,411 | 7,000 |
| 2020 | 17,910 | 19,732[5] | 16,548[6] | 14,000 |
| Intensive Land Use | | | | |
| 1980 | 11,240 | 68,851 | 68,851 | 0 |
| 2000 | 11,240 | 81,050 | 81,050 | 0 |
| 2020 | 11,240 | 130,183 | 130,183 | 0 |
| Forested land[7] | | | | |
| 1980 | 0 | 236,047 | 0 | 0 |
| 2000 | 0 | 234,451 | 0 | 0 |
| 2020 | 0 | 190,318 | 0 | 27,442[8] |
| Unclassified Land | | | | |
| 1980 | 0 | 8,103 | 0 | 0 |
| 2000 | 0 | 0 | 0 | 0 |
| 2020 | 0 | 0 | 0 | 0 |

1 Acreages derived by map measurements and ADP tabulation for the PS&AW study. Other potential not tabulated. Unrounded figures do not denote accuracy beyond the first three significant figures.

2 Includes overbank flooding of main streams.

3 Needed for full agricultural development (see Appendix V, Water-Related Land Resources, chapter 2, Agriculture).

4 According to Appendix VII, Irrigation, there were 1,800 acres (using 3,870 acre feet of water) irrigated in 1966. Irrigation Appendix projections show 1,400 acres irrigated by 1980, 900 acres by 2000, and 1,100 acres by 2020.

5 Includes 2,232 acres of rangeland.

6 Does not agree with Table 8a-3 due to land use changes during time lapse.

7 Includes non-forested land commonly associated with forested areas.

8 Potential irrigation of forests (see Appendix V, chapter 3, Forestry).

Table 8a-5 shows drainage groups in the watersheds of the Green River Basin, with the acreage of land falling into each group. From this and other data the drainage needs for expected land uses in the Basin are derived.

**TABLE 8a-5. Drainage groups in Green Basin[1] (in acres)[2]**

| LINE | Watershed Area No.[3] | River Basins And Watersheds | 01 | 02 | 03 | 04 | 05 | 06 | 07 | 08 | 09 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Green River | | | | | | | | | | | | | | | | | |
| 1 | 0-34 | East Side Green River (Black River) | 6,475 | C | 1,551 | 329 | 0 | 1,113 | 0 | 0 | 0 | 0 | 33,731 | 129 | 141 | 385 | U | 4,090 | 47,944 |
| 2 | 0-35 | West Side Green River (Hill Creek) | 6,410 | 0 | 1,105 | 426 | 0 | 543 | 930 | 0 | 0 | 0 | 11,229 | 7 | 0 | 63 | 0 | 3,788 | 24,501 |
| 3 | 0-37 | Upper Green River | 475 | 529 | 1,029 | 0 | 0 | 362 | 5,129 | 0 | 0 | 0 | 6,692 | 56 | 0 | 76 | 0 | 900 | 15,248 |
| 4 | | Total | 13,360 | 529 | 3,685 | 755 | 0 | 2,018 | 6,059 | 0 | 0 | 0 | 51,652 | 192 | 141 | 524 | 0 | 8,778 | 87,693 |
| | | Puget Sound Drainages | | | | | | | | | | | | | | | | | |
| 5 | 0-29 | West Slope Seattle | 78 | 0 | 138 | 0 | 0 | 481 | 0 | 0 | 0 | 0 | 6,426 | 0 | 0 | 0 | 0 | 0 | 7,123 |
| 6 | 0-36 | Lakota-Des Mointes | 17 | 0 | 172 | 0 | 0 | 388 | 0 | 0 | 0 | 0 | 13,027 | 14 | 0 | 86 | 0 | 0 | 13,704 |
| 7 | | Total | 95 | 0 | 310 | 0 | 0 | 869 | 0 | 0 | 0 | 0 | 19,453 | 14 | 0 | 86 | 0 | 0 | 20,827 |
| 8 | | Grand Total | 13,455 | 529 | 3,995 | 755 | 0 | 2,887 | 6,059 | 0 | 0 | 0 | 71,105 | 206 | 141 | 610 | 0 | 8,778 | 108,520 |

[1] Descriptions of drainage groups are found in the Means to Satisfy Needs section of the Area report.

[2] Unadjusted measurements, 1966, for Puget Sound Area Study. Tabulations by ADP. Read three significant figures.

[3] See Figure 8a-1 for location.

# MEANS TO SATISFY NEEDS

Population forecasts predict about 781,100 people for the Green Basin by 2020. The means used to accomplish the levels necessary to meet the needs of this expected population consist of programs and projects for protection and development of the land and water resources of this Basin. The wise use and development of these resources can supply the spatial needs and aesthetic wants required by an expanding population. The needs as developed in other appendices have been considered in this Appendix as related to the land and water resources of the Basin.

The objectives of the plan for watershed management are to develop the Basin's resources to achieve its potential production of food and fiber as economically justified, to preserve and enhance fish, wildlife, and recreation values in accord with the Fish and Wildlife, and Recreation Appendices, to provide for development of urban areas not subject to floodwater hazard, and to provide spatial needs in keeping with aesthetic qualities of the Area. These objectives will be carried out by various agencies of the Federal and State governments working in close cooperation with each other and with private sources.

## Land Use

Table 8a-1 in Present Status indicates by sub-basins the present land use. Table 8a-6 summarizes by time periods the estimated future use of the land.

## Flooding

Floodwater damage must be prevented to the extent the hazard remaining does not materially exceed other risks before development becomes

**TABLE 8a-6. Estimated future land use.**

| Year | Crop-land (acres) | Range-land (acres) | Forest[1] (acres) | Urban Built-up[2] (acres) | Fresh water (acres) | Misc. uses[3] (acres) | Total (acres) |
|---|---|---|---|---|---|---|---|
| 1980 | 25,000 | 2,232 | 236,047 | 68,851 | 5,950 | 8,103 | 346,183 |
| 2000 | 22,500 | 2,232 | 234,461 | 81,050 | 5,950 | 0 | 346,183 |
| 2020 | 17,500 | 2,232 | 190,318 | 130,183 | 5,950 | 0 | 346,183 |

[1] Includes non-forested land normally associated with forest.

[2] Rural non-farm is assumed to be urban by 1980. Built-up based on average urban density of six persons per acre.

[3] Unspecified uses including land in transitional usage.

practical. Loss is limited to tolerable values by restricting development on hazardous areas.

Watersheds require varied combinations and intensities of management according to the capability of the land and its use. Programs are planned to stabilize land and related water and thus benefit most functional uses of water. Special objectives for improvement may be selected for project purposes.

## PLAN OF DEVELOPMENT

This plan to provide for the satisfaction of the needs, as brought out in the Needs discussion, will utilize the program and project approach, as explained in the Puget Sound Area section. The plan will guide the development of the resources of the Green River Basin to provide for spatial and associated requirements for the expected population of its service area to the year 2020. The Green River offers numerous opportunities for projects and programs that could maintain and increase fish and wildlife production and recreation areas. Two projects previously authorized (costs not included here) will be constructed prior to 1980.

### Projects after 1980

Several projects will be initiated in the 1980-2000 and 2000-2020 periods to remedy existing floodwater and drainage problems and to develop lands toward their potential for continued use. Benefits and benefit-cost ratios have not been computed for projects past 1980. Total installation costs will be $1,800,000. Table 8a-7 gives brief summaries of projects included in this plan.

**TABLE 8a-7. Costs of projects recommended for installation after 1980**

| Watershed Area No. and Name[1] | Project Area (acres) | Struc. Meas. Installation Cost[2] (dollars) |
|---|---|---|
| 1980-2000 | | |
| 0-37 Upper Green River | 200,358 | 1,700,000 |
| Total | 200,358 | 1,700,000 |
| 2000-2020 | | |
| 0-36 Lakota-Des Moines | 16,550 | 100,000 |
| Total | 16,550 | 100,000 |

[1] See Figure 8a-1 for location.

[2] 1967 prices.

### Programs

Program measures refer to on-farm and urban on-site practices which take advantage of improvements brought about by the structural works of improvement, as well as measures for watershed protection, erosion control, and water management. These measures will include seeding of improved grasses and legumes, cover crops, cropland and urban drainage development made possible by structural works of improvement, forest management practices, and irrigation development.

Table 8a-8 shows a breakdown of the various practices for each of the three time periods.

### Summary of Costs

Costs for the Green Basin plan (project costs plus program costs, rounded to the nearest thousand dollars) are expected to be $74,818,000 for the early action period; $80,676,000 for the years 1980-2000; and $79,232,000 for the years 2000-2020. Total cost of the plan will be $234,726,000. See page 2-89 et. seq. for further explanation of costs.

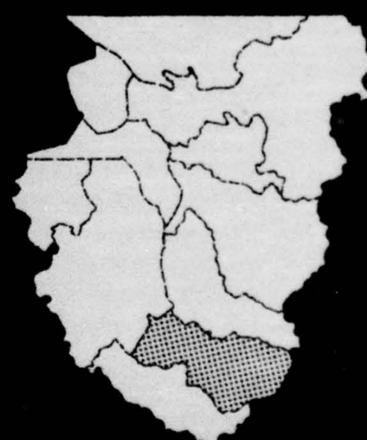
**TABLE 8a-8. Watershed management practices for protection and development, by time periods, Green Basin**

| Practice | Area (acres) | Cost[1] (thousands of dollars) | |
|---|---|---|---|
| **First 15 Years** | | | |
| Technical assistance & management | 271,382[2] | | 7,020 |
| Federal, regular | | 7,020 | |
| Federal, accelerated | | 0 | |
| Installation of practices (non-Federal) | | | 67,798 |
| State & corporate management | | 3,079 | |
| Land treatment | 151,110 | 2,806 | |
| Water management | 7,447 | 2,159 | |
| Urban drainage | 44,262 | 59,754 | |
| Total | | | 74,818 |
| **1980-2000** | | | |
| Technical assistance & management | 259,183[2] | | 12,682 |
| Federal, regular | | 12,239 | |
| Federal, accelerated | | 443 | |
| Installation of practices (non-Federal) | | | 66,294 |
| State & corporate management | | 4,106 | |
| Land treatment | 138,911 | * 2,779 | |
| Water management | 4,964 | * 1,413 | |
| Urban drainage | 42,960 | *57,996 | |
| Total | | | 78,976 |
| **2000-2020** | | | |
| *Technical assistance & management* | 210,050[2] | | 12,678 |
| Federal, regular | | 12,235 | |
| Federal, accelerated | | 443 | |
| Installation of practices (non-Federal) | | | 66,454 |
| State & corporate management | | 4,106 | |
| Land treatment | 89,778 | * 2,108 | |
| Water management | 7,000 | * 2,244 | |
| Urban drainage | 42,960 | * 57,996 | |
| Total | | | 79,132 |

1 Base: 1967 prices, except items asterisked which are 1967 adjusted normalized prices. See page 2-89 et seq. for further explanation of costs.

2 Total acres in Basin involved in program measures.

# Puyallup Basin



# PUYALLUP BASIN

The Puyallup Basin is located largely in Pierce County, although 10 percent of the Basin is located in southern King County.

The western half of this Basin has extensive alluvial flats and gravelly terraces graduating into a large area of rugged mountainous terrain, including Mt. Rainier in the east.

The Puyallup Basin provides the fifth largest valley system in the Puget Sound Area. It drains an area of 992 square miles. The principal tributaries are the White River and the Carbon River. Coastal waters drain 212 square miles, and empty directly into Puget Sound. The Puyallup Basin as a whole drains 1,204 square miles of territory.

# PRESENT STATUS

In 1963[1] the population was 333,800, and projections indicate that by 1980 the population will be 462,000; by 2000, 741,400; and by the year 2020 will reach 1,190,900. Population density at the present time, based on urban and rural non-farm lands, is 2.71 people per acre.

Farming and forestry are two of the main users of land in the basin, and farming is still a very important part of its economy. In the last few years, specialty crops such as bulbs, flower plants, commercial shrubs, and herbs have superseded dairying as the most important product in the farming industry. Poultry, berry, and vegetable production make up an important segment of the Puyallup Basin industry. Total value of farm production is over $13 million annually.

Forest products constitute one of the prime resources of the area, with several large sawmills and wood pulp producing mills being located in the Basin.

Farming and the forest products industry have been among the principal activities in the Puyallup Basin. Other important industries, mainly located near Tacoma, include an oil refinery, an aluminum reduction plant, chemical products, copper smelter, a ferro-alloy plant, pulp mill, and industries related to aircraft manufacturing. Mining activities in the Basin include coal, basalt rock, clay, and sandstone. Recreation is highlighted by sport fishing, as the Puyallup River is a major steelhead fishing stream.

The production of salmon from the Puyallup River provides important contributions to the commercial and sport fisheries of Puget Sound, Strait of Juan de Fuca and Pacific Ocean coastal waters. The economy of the Basin is stimulated and enhanced from this natural resource.

The Puyallup Basin is a significant winter concentration area for migratory waterfowl. Suitable habitat attracts a variety of species. The varied species of upland game which inhabit the Basin include both native members and introduced exotics. A wide variety of fur-bearing animals inhabit the basin along with a number of big-game species.

The outdoor attractions of the Basin include the waters and shorelines of Puget Sound and of the lakes and rivers. There are numerous lakes and miles of rivers throughout the Basin. The most notable recreation area is Mt. Rainier National Park. Point Defiance Park within the city of Tacoma is an excellent large urban park of the type which is needed in heavily populated cities.

The climate of the Basin is conducive to extremes of streamflows. Late fall and winter frequently produce damaging floodflows and conversely midsummer drought produces low flow conditions which are detrimental to fish and wildlife, recreation, and to sanitation within the streams. Potential for development of streams and rivers is limited in many respects unless low flows can be augmented to some degree by structural measures and management practices. Low flow characteristics for streams in the Basin are given in Appendix III, Hydrology.

The present condition of many stream and river channels in the Basin is partly the result of nearly a century of exploitation by man with only the last few years devoted to efforts to protect and rehabilitate the environment. Streambank erosion is severe in areas where sediment and debris is reduce channel capacity.

[1] Population figures for this basin were based on preliminary economic data prepared in 1967 and may be slightly lower than the same data in other appendices.

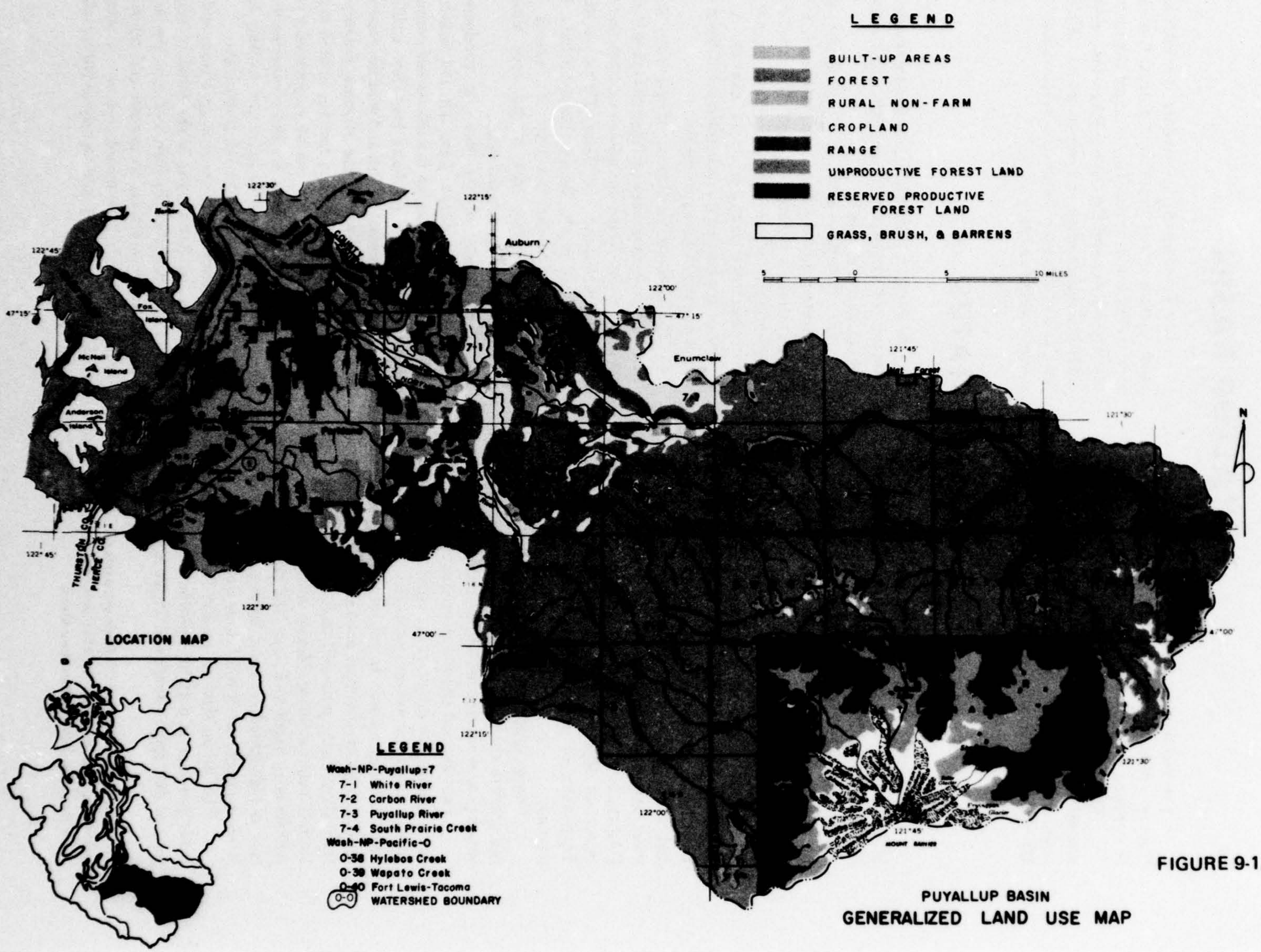



FIGURE 9-1.

PUYALLUP BASIN
GENERALIZED LAND USE MAP

Sediment problems in the Basin occur locally where logging, construction, or farming has resulted in erosion. Some usable land adjacent to rivers has been lost owing to sloughing of banks. The deposition of sediment in reservoirs and at the mouth of the Puyallup River has caused some problems.

## PRESENT LAND USE

The system includes many flood and drainage problem areas which require corrective measures before their potential can be attained. The lower flood plain contains about 27,000 acres of level or gently undulating bottom lands. South of Tacoma, the land becomes relatively level, and problems with winter flooding frequently occur. The eastern reaches of the Basin contain steep, mountainous valleys with turbulent streams (see Figure 9-1). The ownership distribution of the Basin's lands are shown on Figure 9-2.

The broad categories of land use are given in Table 9-1. No attempt is made here to quantify mulitple-use management of lands such as for game habitat, recreation, water quality, or low flow augmentation.

**TABLE 9-1. Present land use by sub-basins[1]**

| Land Use | Puyallup River Basin | Coastal Waters | Total |
|---|---|---|---|
| | (acres) | (acres) | (acres) |
| Cropland | 31,400 | 5,453 | 36,853 |
| Rangeland | 1,778 | 3,905 | 5,683 |
| Forest[2] | 556,637 | 36,702 | 593,339 |
| Rural non-farm | 14,305 | 11,424 | 25,729 |
| Urban built-up | 22,408 | 75,038 | 97,446 |
| Fresh water | 8,396 | 2,901 | 11,297 |
| Total | 634,924 | 135,423 | 770,347 |

[1] Unadjusted measurements, 1966, for Puget Sound Area Study. Tabulations by ADP. First three figures are significant figures for acreages.

[2] Includes non-forested land normally associated with forest.

## SOILS

A medium intensity soil survey is available for most lands outside the national forest and national park boundaries. Lands within the national forests and national parks were mapped from a reconnaissance-type survey.

The mapping units are discussed in the soil survey reports for Pierce and King Counties and their locations are shown on maps. The soil survey report is available in libraries and in local offices of the United States Department of Agriculture.

The principal properties of each soil series are tabulated in Exhibit 1, Table 6 of this Appendix. Interpretations of data for each soil series are provided in subsequent tables of the Exhibit.

The total land area of 759,000 acres in the Puyallup Basin has a medium-intensity survey on 454,200 acres and a low-intensity survey on 304,800 acres. Of the 454,200 acres, 284,400 acres are classified in Land Capability Classes II through VI, 163,000 acres are classified in Land Capability Class VII, and 6,900 acres in Class VIII (Figure 9-3).

Lands in the Land Use Capability Classes II through VI (284,400 acres) have the greatest potential for development; i.e., changed use or improved use. Land Use Capability Classes II, III, and IV may be suited for either crops or urban uses, and Class VI has potential for urban development. Most of the Class II and Class VI has potential for urban development. Most of the Class II and Class III lands in this basin are subject to flooding and have wetness conditions which present hazards for many developed uses. Class VII is expected to be largely limited to forest use and Class VIII for recreation or aesthetic use.

The soil types in the Area having a medium intensity survey have been classified into land use capability classes and their primary and secondary subclasses, and capability units (see Exhibit 1, Tables 9 and 10). Lands having only reconnaissance surveys are roughly grouped into capability classes.

Tables 9-2 and 9-3 which follow give a tabulation of capability subclasses and specific wetness conditions for surveyed lands in this basin.

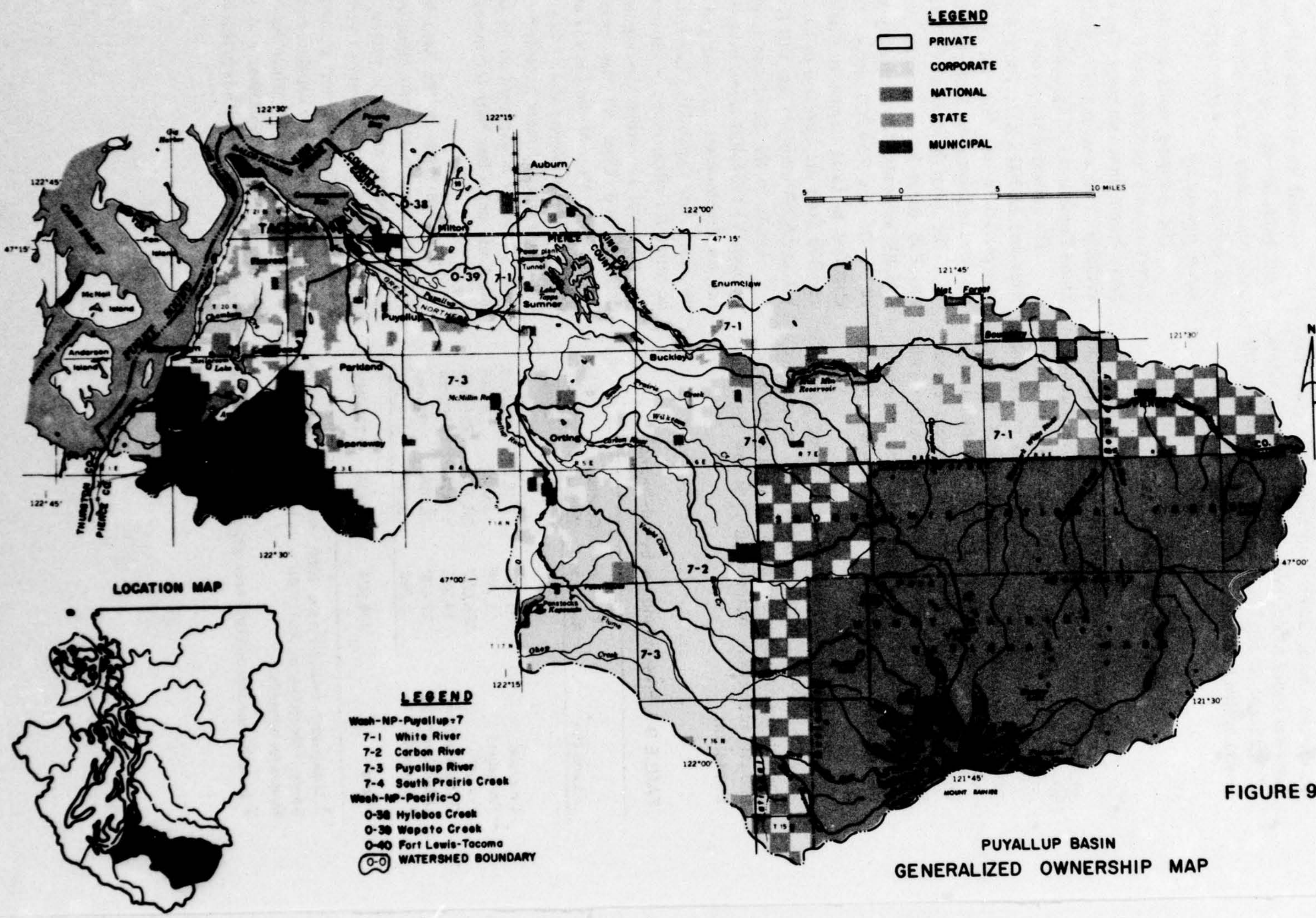



FIGURE 9-2.

PUYALLUP BASIN
GENERALIZED OWNERSHIP MAP

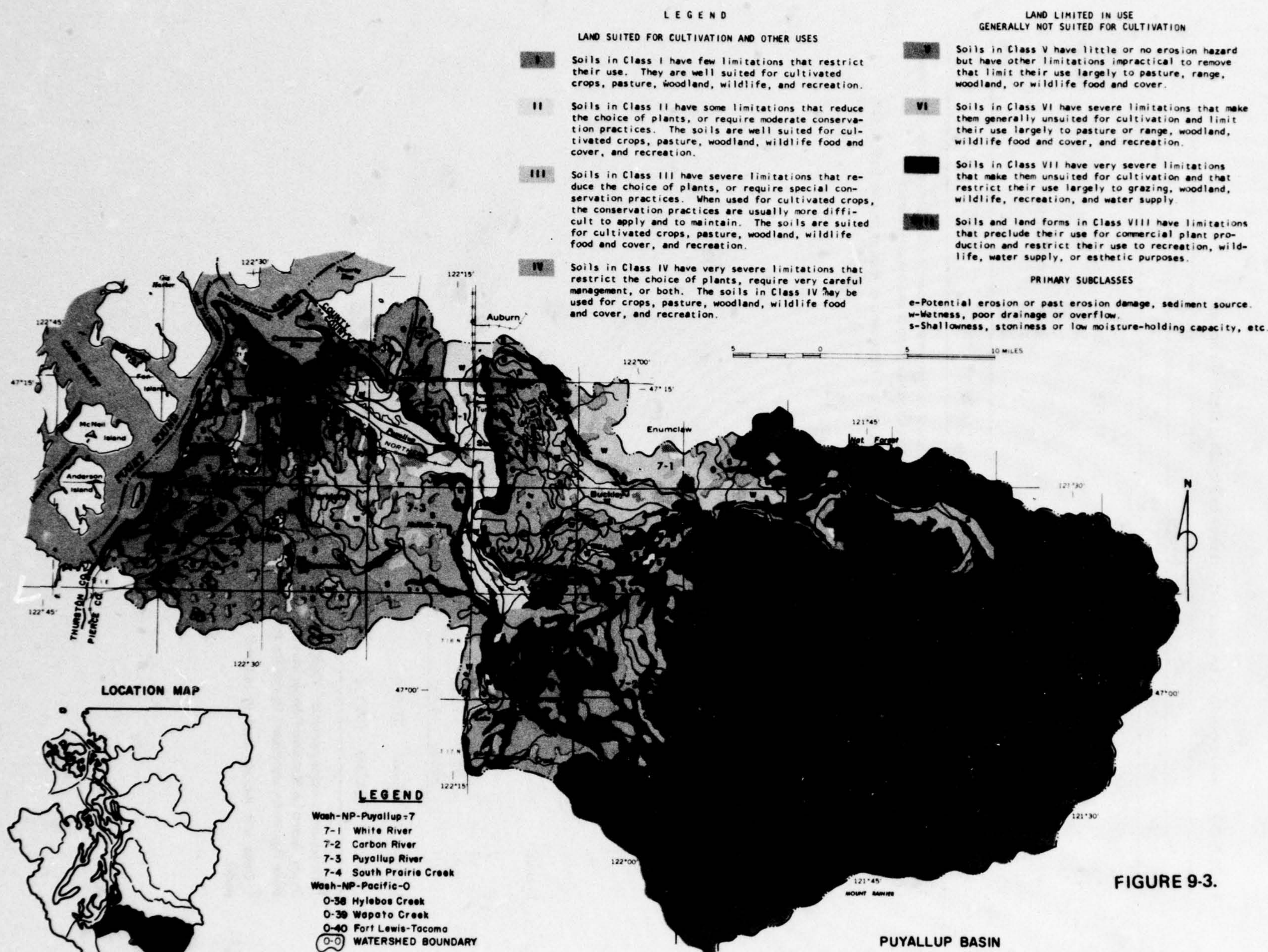



FIGURE 9-3.

PUYALLUP BASIN
GENERALIZED LAND CAPABILITY MAP
Class and Subclass

**TABLE 9-2. Land conditions by capability classes in Puyallup Basin (in acres)[1]**

| Class | e | w | s | ew | es | we | ws | se | sw | Class Total |
|---|---|---|---|---|---|---|---|---|---|---|
| | Subclasses[2] | | | | | | | | | |
| II | | | | | | | 26,923 | | | 26,923 |
| III | | | | 2,177 | | 17,415 | 20,242 | | | 39,834 |
| IV | | | 49,520 | 64,486 | 35 | | 9,396 | 4,954 | | 128,391 |
| V | | | | | | | 219 | | | 219 |
| VI | | | 24,402 | 13,446 | 22,045 | | 5,247 | 23,864 | | 89,004 |
| VII | | | | | 161,663 | | 1,313 | | | 162,976 |
| VIII | | | 2,011 | 114 | | | 4,737 | | | 6,862 |
| TOTAL | | | 75,933 | 80,223 | 183,743 | 17,415 | 68,077 | 28,818 | | 454,209 |

[1] Unadjusted measurements, 1966, for Puget Sound Area Study, based on National Cooperative Soil Survey maps. First three figures are significant figures for acreages. Does not include land within national forests and national parks.

[2] *Letters for subclasses denote hazards or conditions that affect* land use and treatment: e—erosion; w—wetness; s—soil.

**TABLE 9-3. Land with wetness condition by capability classes, Puyallup Basin (in acres) [1]**

| Land Capability Classes | All land in basins[2]: Total All Land | All land in basins[2]: With Wetness Condition | Cropland in basin: Total Cropland (est.) | Cropland in basin: Cropland With Wetness Condition (est.) |
|---|---|---|---|---|
| II | 26,923 | 26,923 | 25,577 | 25,577 |
| III | 39,834 | 39,834 | 1,967 | 1,967 |
| IV | 128,391 | 73,882 | 9,309 | 5,728 |
| Subtotal | 195,148 | 140,639 | 36,853 | 33,272 |
| V | 219 | 219 | 0 | 0 |
| VI | 89,004 | 18,693 | 0 | 0 |
| VII | 162,976 | 1,313 | 0 | 0 |
| VIII | 6,862 | 4,851 | 0 | 0 |
| Subtotal | 259,061 | 25,076 | 0 | 0 |
| TOTAL | 454,209 | 165,715 | 36,853 | 33,272 |

[1] Unadjusted measurements, 1966, for Puget Sound Area Study, based on National Cooperative Soil Survey maps. First *three figures are significant figures for acreages.*

[2] Does not include land in national forests and national parks.

# PRESENT AND FUTURE NEEDS

## EVALUATION OF PRESENT SITUATION

In the Puyallup Basin, three broad categories of needs—protection from floodwater damage, measures for watershed protection and rehabilitation, and measures for water management—are present in varying degrees of intensity according to land use. About 36,853 acres are devoted to cropland use at the present time; 593,339 acres are in forest (including some areas of non-forested land); 5,683 acres are in rangeland; and 123,175 acres are in more intensive land uses. According to Appendix VII, Irrigation, 3,700 acres were under irrigation in 1966.

## ESTIMATED FUTURE NEEDS

Determination of needs is made on the basis of multiple-use management and the categories of floodwater damage reduction. Watershed protection and rehabilitation measures, and water management contain the practices needed for development under the concept. Development needed in forestry and farming is to keep pace with other needs as the population increases and reach the level required by 2020.

Future needs are given in acres of land to be treated. Intensity or degree of practice application will increase with use. Management practices for enhancement of multiple-use objectives may require several practices on the same acres of land. A partial listing of practices used is given in Tables 2-18 and 2-19 in the Puget Sound Area section of this Appendix under Means to Satisfy Needs.

The projected rapid rise in population, with its requirements for space, recreation, and other land and water needs, makes it necessary to initiate an early action program of development to avoid costly misuse of the land resource. An obvious need in this Basin is for improved floodwater damage reduction on the Puyallup River flood plain, particularly upstream from the town of Sumner, as described in Appendix XII, Flood Control, and for flood prevention and drainage facilities to be installed on five watersheds considered to be in need of improvements to accommodate orderly development of the Basin. Details of these early action projects are found in the Means to Satisfy Needs section.

The Puyallup Basin, especially between Tacoma and Puyallup and on the Fort Lewis Military Reservation, is experiencing an industrial and residential boom. This rapid increase is expected to continue in the future and the loss of prime agricultural land is considered a certainty unless proper zoning laws are enacted.

The estimated number of acres, according to land use, that will require protective and development measures by the years 1980, 2000, and 2020 are tabulated in Table 9-4. The same land area may require more than one of these practices.

**TABLE 9-4. Future needs for watershed management [1]**

| Year | Floodwater Damage[2] Reduction[3] (acres) | Watershed Protection & Rehab.[3] (acres) | Drainage Improvement[3] (acres) | Irrigation Development[3] [4] (acres) |
|---|---|---|---|---|
| Cropland | | | | |
| 1980 | 33,400 | 39,083[5] | 11,952 | 8,000 |
| 2000 | 33,400 | 37,383[5] | 19,920 | 10,000 |
| 2020 | 33,400 | 35,683[5] | 26,559[6] | 25,000 |
| Intensive Land Use | | | | |
| 1980 | 14,660 | 123,175 | 123,175 | 0 |
| 2000 | 14,660 | 123,567 | 123,567 | 0 |
| 2020 | 14,660 | 198,483 | 198,483 | 0 |
| Forested Land[7] | | | | |
| 1980 | 0 | 593,339 | 0 | 0 |
| 2000 | 0 | 593,339 | 0 | 0 |
| 2020 | 0 | 524,884 | 0 | 81,900[8] |
| Unclassified Land | | | | |
| 1980 | 0 | 3,453 | 0 | 0 |
| 2000 | 0 | 4,761 | 0 | 0 |
| 2020 | 0 | 0 | 0 | 0 |

1 Acreages derived by map measurements and ADP tabulation for the PS&AW study. Other potential not tabulated. Unrounded figures do not denote accuracy beyond the first three significant figures.

2 Includes overbank flooding of main streams.

3 Needed for full agricultural development (see Appendix V, Water–Related Land Resources, chapter 2, Agriculture).

4 According to Appendix VII, Irrigation, there were 3,700 acres (using 8,769 acres feet of water) irrigated in 1966. Irrigation Appendix projections show 6,200 acres irrigated by 1980, 11,200 acres by 2000, and 13,700 acres by 2020.

5 Includes 5,683 acres of rangeland.

6 Does not agree with Table 9-3 due to land use changes during time lapse.

7 Includes some non-forested land commonly associated with forests.

8 *Potential irrigation of forests (see Appendix V, Chapter 3, Forestry).*

Table 9-5 shows drainage groups in the watersheds of the Puyallup Basin, with the acreage of land falling into each group. From this and other data the drainage needs for expected land uses in the Basin are derived.

**TABLE 9-5. Drainage groups in Puyallup Basin[1] (in acres)[2]**

| LINE | Watershed Area No.[3] | River Basins And Watersheds | 01 | 02 | 03 | 04 | 05 | 06 | 07 | 08 | 09 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Puyallup River | | | | | | | | | | | | | | | | | |
| 1 | 7-1 | White River | 4,505 | 301 | 1,775 | 617 | 0 | 497 | 16,493 | 8 | 102 | 20 | 16,500 | 374 | 15 | 20 | 0 | 6,311 | 47,538 |
| 2 | 7-2 | Carbon River | 425 | 0 | 30 | 0 | 0 | 73 | 1,208 | 0 | 5,983 | 0 | 105 | 72 | 10 | 27 | 0 | 1,430 | 9,363 |
| 3 | 7-3 | Puyallup River | 5,634 | 0 | 553 | 67 | 3 | 1,261 | 11,292 | 143 | 10,959 | 37 | 6,692 | 1,017 | 165 | 76 | 0 | 8,735 | 46,634 |
| 4 | 7-4 | South Praire Creek | 107 | 0 | 104 | 0 | 3 | 146 | 2,619 | 10 | 4,219 | 0 | 1,051 | 55 | 30 | 105 | 0 | 711 | 9,160 |
| 5 | | Total | 10,671 | 301 | 2,462 | 684 | 6 | 1,977 | 31,612 | 161 | 21,263 | 57 | 24,348 | 1,518 | 220 | 228 | 0 | 17,187 | 112,695 |
| | | Puget Sound Drainages | | | | | | | | | | | | | | | | | |
| 6 | 0-38 | Hylebos Creek | 1,202 | 0 | 376 | 1 | 0 | 654 | 334 | 1 | 34 | 152 | 9,159 | 617 | 0 | 122 | 0 | 188 | 12,840 |
| 7 | 0-39 | Wapato Creek | 1,812 | 0 | 24 | 0 | 0 | 22 | 530 | 0 | 2 | 0 | 1,173 | 753 | 11 | 8 | 0 | 1,039 | 5,374 |
| 8 | 0-40 | Fort Lewis–Tacoma | 3,668 | 0 | 995 | 27 | 0 | 888 | 5,449 | 23 | 647 | 215 | 21,297 | 1,120 | 388 | 19 | 0 | 65 | 34,801 |
| 9 | | Total | 6,682 | 0 | 1,395 | 28 | 0 | 1,564 | 6,313 | 24 | 683 | 367 | 31,629 | 2,490 | 399 | 149 | 0 | 1,292 | 53,015 |
| 10 | | Grand Total | 17,353 | 301 | 3,857 | 712 | 6 | 3,541 | 37,925 | 185 | 21,946 | 424 | 55,977 | 4,008 | 619 | 377 | 0 | 18,479 | 165,710 |

1 Descriptions of drainage groups, are found in the Means to Satisfy needs section of the Area report.

2 Unadjusted measurements, 1966, for Puget Sound Area Study. Tabulations by ADP. Read three significant figures.

3 See Figure 9-1 for location.

# MEANS TO SATISFY NEEDS

Population in the Puyallup Basin is expected to reach 1,190,900 people by 2020. To satisfy the needs of this many people a plan consisting of programs and projects for protection and development of the land and water resources has been devised. The wise use and development of these resources can supply the spatial needs and aesthetic wants of the growing population. The needs as developed in other appendices have been considered in this appendix as related to the land and water resources of the Basin.

The objectives of the plan for watershed management are to develop the Basin's resources to achieve its potential production of food and fiber as economically justified, to preserve and enhance fish, wildlife, and recreation values in accord with the Fish and Wildlife, and Recreation Appendices, to provide for development of urban areas not subject to floodwater hazard, and to provide spatial needs in keeping with aesthetic qualities of the Area. These objectives will be carried out by various agencies of the Federal and State governments working in close cooperation with each other and with private sources.

## Land Use

Table 9-1 in Present Status indicates by subbasins the present land use. Table 9-6 summarizes by time periods the estimated future use of the land.

**TABLE 9-6. Estimated future land use**

| Year | Cropland (acres) | Rangeland (acres) | Forest[1] (acres) | Urban Built-up[2] (acres) | Fresh water (acres) | Misc. uses[3] (acres) | Total (acres) |
|---|---|---|---|---|---|---|---|
| 1980 | 33,400 | 5,683 | 593,339 | 123,175 | 11,297 | 3,453 | 770,347 |
| 2000 | 31,700 | 5,683 | 593,339 | 123,567 | 11,297 | 4,761 | 770,347 |
| 2020 | 30,000 | 5,683 | 524,884 | 198,483 | 11,297 | 0 | 770,347 |

1 Includes non-forest land normally associated with forest.

2 Rural non-farm is assumed to be all urban by 1980. Built-up is based on average urban density of six persons per acre.

3 Unspecific uses including land in transitional usage.

## Flooding

Floodwater damage must be prevented to the extent the hazard remaining does not materially exceed other risks before development becomes practical. Loss is limited to tolerable values by restricting development on hazardous areas.

Watersheds require varied combinations and intensities of management according to the capability of the land and its use. Programs are planned to stabilize land and related water and thus benefit most functional uses of water. Specific objectives for improvement may be selected for project purposes.

## PLAN OF DEVELOPMENT

This plan to provide for the satisfaction of the needs as brought out in the Needs discussion will utilize the program and project approach, as explained in the Puget Sound Area section. The plan will guide the development of the resources of the Puyallup Basin to provide for spatial and associated requirements for the expected population of its service area to the year 2020. Flood prevention and low flow augmentation projects would be highly beneficial for fish, wildlife, and recreation areas on a number of streams, particularly the Carbon and Upper White Rivers.

### Early Action Projects

Several projects will be initiated prior to 1980 to remedy existing floodwater and drainage problems and to develop lands toward their potential for continued use. Table 9-7 describes projects in the early action plan.

**The Algona-Pacific Watershed Area 7-1, Figure 9-1** outlets into the White River upstream from Sumner. It occupies the relatively level flood plain and a portion of the glacial morain on the west side of the White River. The valley is utilized for agricultural and urban purposes and the hill land is heavily forested mostly in mixed stands of Douglas-fir and red alder. This area is rapidly being urbanized and none of it is expected to remain in commercial forest. The steep slopes of the hills is a critical erosion area and should remain either in forest or great care should be taken in the developments which are placed in this area.

The project is designed for flood prevention of agricultural and urban areas, and drainage of agricultural lands. The area contains 6,457 acres of land, of which 1,502 acres are cropland, 1,435 acres are forest, and 3,520 acres are rural non-farm and urban.

The works of improvement will consist of 12 miles of improved and stabilized channel.

Installation cost is estimated to be $594,130, of which the Federal share is $443,790, and the local share is $150,340. Benefits from damage reduction and drainage will provide a benefit-cost ratio of 1.6 to 1. To achieve benefits made possible by the structural works and other management during a 15-year period, local interests will install necessary land treatment measures for erosion control and flood management, costing approximately $108,810, drainage measures estimated to cost $225,466, and forest protection and management practices costing

**TABLE 9-7. Costs and benefited areas, early action projects recommened for installation by 1980**

| Watershed Area No. and Name[1] | Project Area (acres) | Project Structural Measures Cost[2] (dollars) | Floodwater Protection (acres) | Drainage Improvement (acres) |
|---|---|---|---|---|
| 7-1 Pacific-Algona[3] | 6,457 | 594,000 | 1,688 | 1,444 |
| 7-3 Clear Creek[4] | 8,060 | 1,901,000 | 2,364 | 6,587 |
| 0-38 Hylebos Creek | 16,000 | 642,000 | 2,376 | 1,258 |
| 0-39 Wapato Creek | 6,407 | 979,000 | 3,243 | 1,699 |
| 0-40 Fort Lewis-Tacoma[5] | 88,092 | 856,000 | 4,990 | 805 |
| Total | 125,016 | 4,972,000 | 14,661 | 11,793 |

1 See Figure 9-1 for location.
2 1967 prices.
3 Part of White River Watershed.
4 Part of Puyallup River Watershed.
5 Part of watershed.

$32,546, for a total of $366,822. The total cost of installing the structural measures and the land treatment measures is $960,952.

**Clear Creek Watershed Area 7-3, Figure 9-1** is located on the east side and adjacent to the city of Tacoma. The watershed is drained by four streams which originate on the terrace upland and flow northward into the flood plain of the Puyallup River. These streams join together in Clear Creek and outlet into the Puyallup River. Flood and drainage problems on the upland terrace area are caused by inadequate channels and floods on the flood plain are due to both inadequate channels and poor outlets.

The forest land is restricted to the upland portion of the watershed. The most critical erosion area is where the uplands rise sharply from the bottom land and protective measures are needed on the slope to insure stability of the soil.

The project is designed for flood prevention of agricultural and urban areas, and drainage of agricultural lands. The area included in this watershed contains 8,060 acres, of which 790 acres are cropland, 990 acres are forest, 6,165 acres rural non-farm and urban, and 115 acres in miscellaneous uses.

The works of improvement will consist of 21 miles of improved and stabilized channel and one outlet structure consisting of floodgates and pump.

Installation cost is estimated to be $1,900,660, of which the Federal share is $1,101,400, and the local share is $799,260. Benefits from damage reduction and drainage will provide a benefit-cost ratio of 1.3 to 1. To achieve benefits made possible by the structural works and other management during a 15 year period, local interests will install necessary land treatment measures for erosion control and flood management, costing approximately $57,240, drainage measures expected to cost $1,197,187 and forest protection and management practices costing $22,453 for a total of $1,276,880. The total cost of installing the structural measures and the land treatment measures is $3,177,540.

**Hylebos Creek Watershed Area 0-38, Figure 9-1** is located between Seattle and Tacoma and outlets into Commencement Bay at Tacoma. The lower part of the watershed, the portion on the Puyallup River flood plain, is agricultural and urban; however, this will probably become industrial in the not too distant future. Flood and drainage problems are caused by inadequate channels and lack of maintenance of existing channels.

All the upland of this watershed was well forested with young growth Douglas-fir up until 30 years ago. Since then there has been a gradual acceleration of urbanization until only a few blocks of forest cover remain, and even these are dotted with suburban residences. Some effort should be made to reserve part of these remaining tracts for parks. Development around the many small lakes should be planned to preserve the attractiveness of the landscape and prevent pollution of the water resources. The steep slope from the upland plateau to the valley is the most critical erosion area and developments here should be established with care.

The project is designed for flood prevention of agricultural and urban areas, and drainage of agricultural lands. The area included contains 16,000 acres, of which 1,281 acres are cropland, 7,239 acres are forest, 7,303 acres rural non-farm and urban, and 177 acres miscellaneous uses.

The works of improvement will consist of 7 miles of improved and stabilized channel and one outlet structure consisting of floodgates and pump.

Installation cost is estimated to be $642,480, of which the Federal share is $386,130, and the local share is $256,350. Benefits from damage reduction and drainage will provide a benefit-cost ratio of 1.5 to 1. To achieve benefits made possible by the structural works and other management during a 15-year period, local interests will install necessary land treatment measures for erosion control and flood management, costing approximately $92,812, drainage measures expected to cost $281,375, and forest protection and management practices costing $164,180 for a total of $538,367. The total cost of installing the structural measures and the land treatment measures is $1,180,847.

**Wapato Creek Watershed Area 0-39, Figure 9-1** is entirely on the north side of the flood plain of the Puyallup River and outlets into Commencement Bay. The lower end of the watershed is an industrial area and this area is expanding up the valley. Most of the area is a high producing agricultural region; however, it is adjacent to both Tacoma and Puyallup and urbanization is proceeding rapidly. Only 13 percent of the land remains in forest and this forest land is restricted to the upland portion. The most critical erosion area is where the uplands rise sharply from the bottom land. Protective measures are needed on this slope to insure stability of the soil.

The project as designed is for flood prevention of agricultural and urban areas, and drainage of agricultural lands. The area contains 6,407 acres of

land of which 1,699 acres are cropland, 829 acres are forest, 3,859 acres rural non-farm and urban, and 20 acres miscellaneous uses.

The works of improvement will consist of 7 miles of improved and stabilized channel and one outlet structure consisting of floodgates and pump.

Installation cost is estimated to be $979,310, of which the Federal share is $604,470, and the local share is $374,840. Benefits from damage reduction and drainage will provide a benefit-cost ratio of 1.3 to 1. To achieve benefits made possible by the structural works and other management during a 15-year period, local interests will install necessary land treatment measures for erosion control and flood management, costing approximately $123,098, drainage measures expected to cost $365,867, and forest protection and management practices costing $18,802, for a total of $507,767. The total cost of installing the structural measures and the land treatment measures is $1,487,077.

**Clover Creek Watershed Area 0-40, Figure 9-1** is located on the south and west side of Tacoma and flows through McChord Air Force Base. Clover Creek is tributary to Steilacoom Lake which in turn outlets through Chambers Creek and Chambers Bay into Puget Sound.

Much of the area within this watershed is urban and industrial. Some forest remains but urbanization is gradually eliminating the forest.

Clover Creek has inadequate or blocked channels and a flat gradient. Agricultural areas in the upper watershed are handicapped by floodwater and poor drainage conditions.

The project is designed for flood prevention of agricultural and urban areas, and drainage of agricultural lands. The area contains 88,092 acres, of which 1,978 acres are cropland, 22,907 acres are forest, 60,241 acres rural non-farm and urban, and 2,966 acres miscellaneous uses.

The works of improvement will consist of 14 miles of improved and stabilized channels.

Installation cost is estimated to be $855,625, of which the Federal share is $489,190, and the local share is $366,435. Benefits from damage reduction and drainage will provide a benefit-cost ratio of 1.6 to 1. To achieve benefits made possible by the structural works and other management during a 15-year period, local interests will install necessary land treatment measures for erosion control and flood management, costing approximately $143,302, drainage measures expected to cost $166,868, and forest protection and management practices costing $519,531, for a total of $829,701. The total cost of installing the structural measures and the land treatment measures is $1,685,326.

## Projects after 1980

Projects for the years 1980-2000 are shown in Table 9-8 with their expected costs. Benefits and benefit-cost ratios have not been computed past 1980. Total installation costs are anticipated to be $4,167,000.

**TABLE 9-8. Costs of projects recommended for installation after 1980**

| Watershed Area No. and Name[1] | Project Areas | Struc. Meas. Installation Cost[2] |
|---|---|---|
| | (acres) | (dollars) |
| 1980-2000 | | |
| 7-1 White River [3] | 307,682 | 1,667,000 |
| 7-2 Carbon River | 87,590 | 200,000 |
| 7-3 Puyallup River [3] | 160,763 | 1,500,000 |
| 7-4 South Prairie Creek | 55,976 | 800,000 |
| Total | 612,011 | 4,167,000 |

1 See Figure 9-1 for location.

2 1967 prices.

3 Portions of watersheds to be completed.

## Programs

Program measures refer to on-farm and urban on-site practices which take advantage of improvements made possible by the strucutral works of improvement, as well as measures for watershed protection, erosion control, and water management. These measures will include seeding of improved grasses and legumes, cover crops, cropland and urban drainage development made possible by structural works of improvement, forest management practices, and irrigation development.

Table 9-9 shows a breakdown of the various practices for each of the three time periods.

## Summary of Costs

Costs for the Puyallup Basin plan (project costs plus program costs, rounded to the nearest thousand dollars) are expected to be $140,644,000 for the early action program; $98,290,000 for the years 1980-2000; and $138,264,000 for the years 2000 through 2020. Total cost of the plan will be $377,198,000. See page 2-89 et seq.; also page 2-95, Table 2-20, for further explanation of costs.

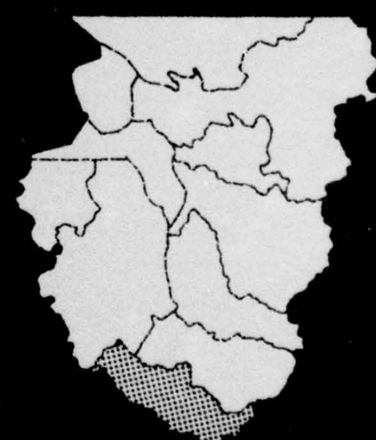
**TABLE 9-9. Watershed management practices for protection and development, by time periods, Puyallup Basin**

| Practices | Area (acres) | Cost[1] (thousands of dollars) | |
|---|---|---|---|
| **First 15 Years** | | | |
| Technical assistance & management | 635,875[2] | | 10,539 |
| Federal, regular | | 10,094 | |
| Federal, accelerated | | 445 | |
| Installation of practices (non-Federal) | | | 125,133 |
| State & corporate management | | 7,897 | |
| Land treatment | 325,701 | 3,745 | |
| Water management | 11,952 | 2,790 | |
| Urban drainage | 82,001 | 110,701 | |
| Total | | | 135,672 |
| **1980-2000** | | | |
| Technical assistance & management | 635,483[2] | | 19,764 |
| Federal, regular | | 19,171 | |
| Federal, accelerated | | 593 | |
| Installation of practices (non-Federal) | | | 74,359 |
| State & corporate management | | 10,529 | |
| Land treatment | 325,309 | * 4,957 | |
| Water management | 14,607 | * 2,759 | |
| Urban drainage | 41,566 | * 56,114 | |
| Total | | | 94,123 |
| **2000-2020** | | | |
| Technical assistance & management | 560,567[2] | | 19,564 |
| Federal, regular | | 19,564 | |
| Federal, accelerated | | 0 | |
| Installation of practices (non-Federal) | | | 118,700 |
| State & corporate management | | 10,529 | |
| Land treatment | 250,393 | * 4,034 | |
| Water management | 15,000 | * 3,000 | |
| Urban drainage | 74,916 | *101,137 | |
| Total | | | 138,264 |

1 Base: 1967 prices, except items asterisked which are 1967 adjusted normalized prices. See page 2-89 et seq. for further explanation of costs.

2 Total acres in Basin involved in program measures.

# Nisqually-Deschutes Basins



# NISQUALLY BASIN

The Nisqually Basin includes parts of three counties. About 60 percent of the Basin lies in southern Pierce County, 30 percent in northern Lewis County, and the remaining 10 percent in northeastern Thurston County.

The Nisqually River drains an area of approximately 720 square miles. The principal tributaries are Muck Creek and Mashel River, which enters the Nisqually River below LaGrande Canyon.

## PRESENT STATUS

In 1963 the population was 19,500, and projections of population indicate that by 1980 it will be 22,000; by 2000, 31,700; and by the year 2020 will reach 46,100. Present population density, based on urban and rural non-farm lands, is 1.65 people per acre.

Forests are by far the biggest user of land in the Basin, with cropland running third. Farming is of a mixed variety. Livestock raising, dairying, berry growing, poultry raising, and specialty crops, such as bulbs, flower plants, commercial shrubs, and herbs play an important part in the economic welfare of the Basin. The total value of farm production is over $10 million annually.

Logging, lumbering, and the production of forest products have always been the Basin's economic mainstay. Forested lands, including non-forested areas normally associated with forest, comprise approximately 380,000 acres. Farming, although not as important as the forest industry, makes use of almost 30,000 acres within the Basin. Electric power is generated at the Alder Dam near Elbe. Fort Lewis, a large army training facility, is located partly within the Nisqually Basin and plays a substantial part in the Basin's economy. Recreation, especially hunting and fishing, is important to the economy of the Basin.

The Nisqually River Basin present considerable stream and streambed area suitable for anadromous fish use. These fish inhabit the mainstem Nisqually River for some 42 miles to the city of Tacoma dam at LaGrande. Accessible tributary streams offer approximately 80 additional miles of suitable spawning and rearing area.

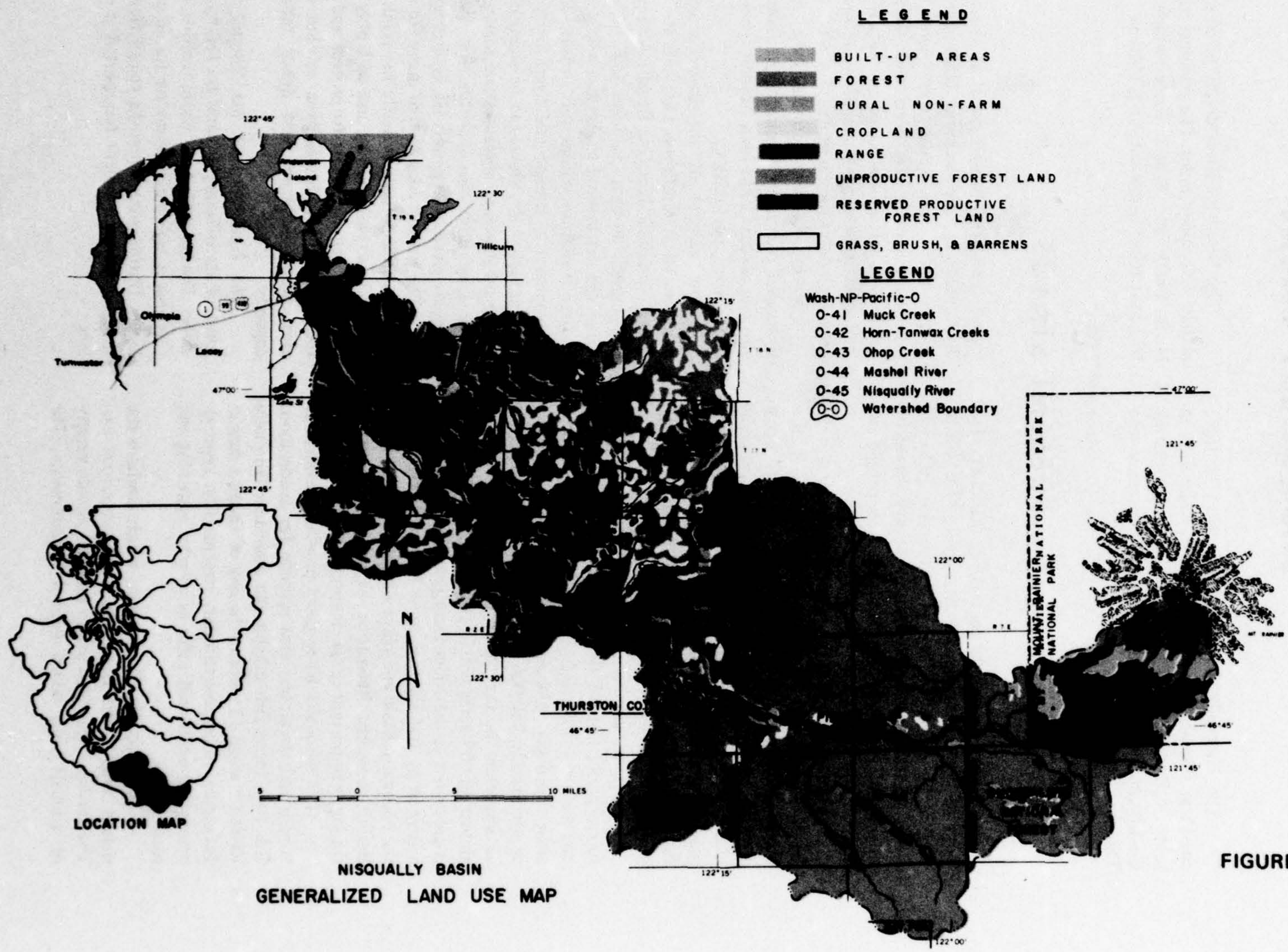
The Nisqually flood plain, which contains the richest soils of the Basin, has heavy waterfowl use. The fur-bearing animal group includes a wide variety of animals with varied habitat requirements. The varied species of upland game are the most widely distributed of the major wildlife groups. Native species utilize the native wood land habitat and introduced exotics have been established in the area devoted to agriculture. Large amounts of the Basin's land area is in some form of woodland cover and provides habitat for big game.

Mount Rainier National Park is the most significant recreation feature of the Basin. There are also numerous lakes and several rivers affording recreation opportunities.

The climate of the Basin is conducive to extremes of streamflows. Late fall and winter frequently produce damaging floodflows and conversely midsummer drought produces low flow conditions which are detrimental to fish and wildlife, recreation, and to sanitation within the streams. Potential for development of streams and rivers is limited in many respects unless low flows can be augmented to some degree by structural measures and management practices. Low flow characteristics for streams in the Basin are given in Appendix III, Hydrology.

The present condition of many stream and river channels in this Basin is partly the result of nearly a century of exploitation by man with only the last few years devoted to efforts to protect and rehabilitate the environment. Streambank erosion is severe in areas where sediment and debris reduce channel capacity.

The headwaters of the Nisqually River and some of its tributary streams are fed by glacial melt water. During periods of warm weather runoff from this area is high and streams are turbid and sediment laden. During winter months glacial flow is less and the amount of sediment transported is considerably less.




NISQUALLY BASIN
GENERALIZED LAND USE MAP

FIGURE 10-1.

## PRESENT LAND USE

The Nisqually Basin provides the sixth largest valley system in the Puget Sound Area. The system includes many flood and drainage problem areas which require coreective measures before their potential can be attained. The lower flood plain contains about 6,000 acres of level or gently undulating river bottom lands. Much of the cropland is above the flood plain on benchland terraces. The eastern portion of the Basin has rugged terrain reaching an elevation of 14,408 feet at the summit of Mount Rainier (see Figure 10-1). The ownership distribution of the Basin's lands are shown on Figure 10-2.

The broad categories of land use are given in Table 10-1 which follows. No attempt is made here to quantify multiple-use management of lands such as for game habitat, recreation, water quality, or low flow augmentation.

**TABLE 10-1. Present land use** [1]

| Land Use | Nisqually Basin (acres) | Total (acres) |
|---|---|---|
| Cropland | 29,254 | 29,254 |
| Rangeland | 34,008 | 34,008 |
| Forest[2] | 379,675 | 379,675 |
| Rural non-farm | 6,368 | 6,368 |
| Urban Built-up | 5,481 | 5,481 |
| Fresh water | 7,468 | 7,468 |
| Total | 462,254 | 462,254 |

[1] Unadjusted measurements, 1966, for Puget Sound Area Study. Tabulations by ADP. First three figures are signficant figures for acreages.

[2] Includes alpine and non-forested areas normally associated with forest.

## SOILS

A medium intensity soil survey is available for most lands outside the national forest and national park boundaries. Lands within the national forest and national parks were mapped froma a reconnaissance-type survey.

The mapping units are discussed in the soil survey reports for Pierce, Lewis and Thurston Counties and their locations are shown on maps. The soil survey report is available in libraries and in local offices of the United States Department of Agriculture.

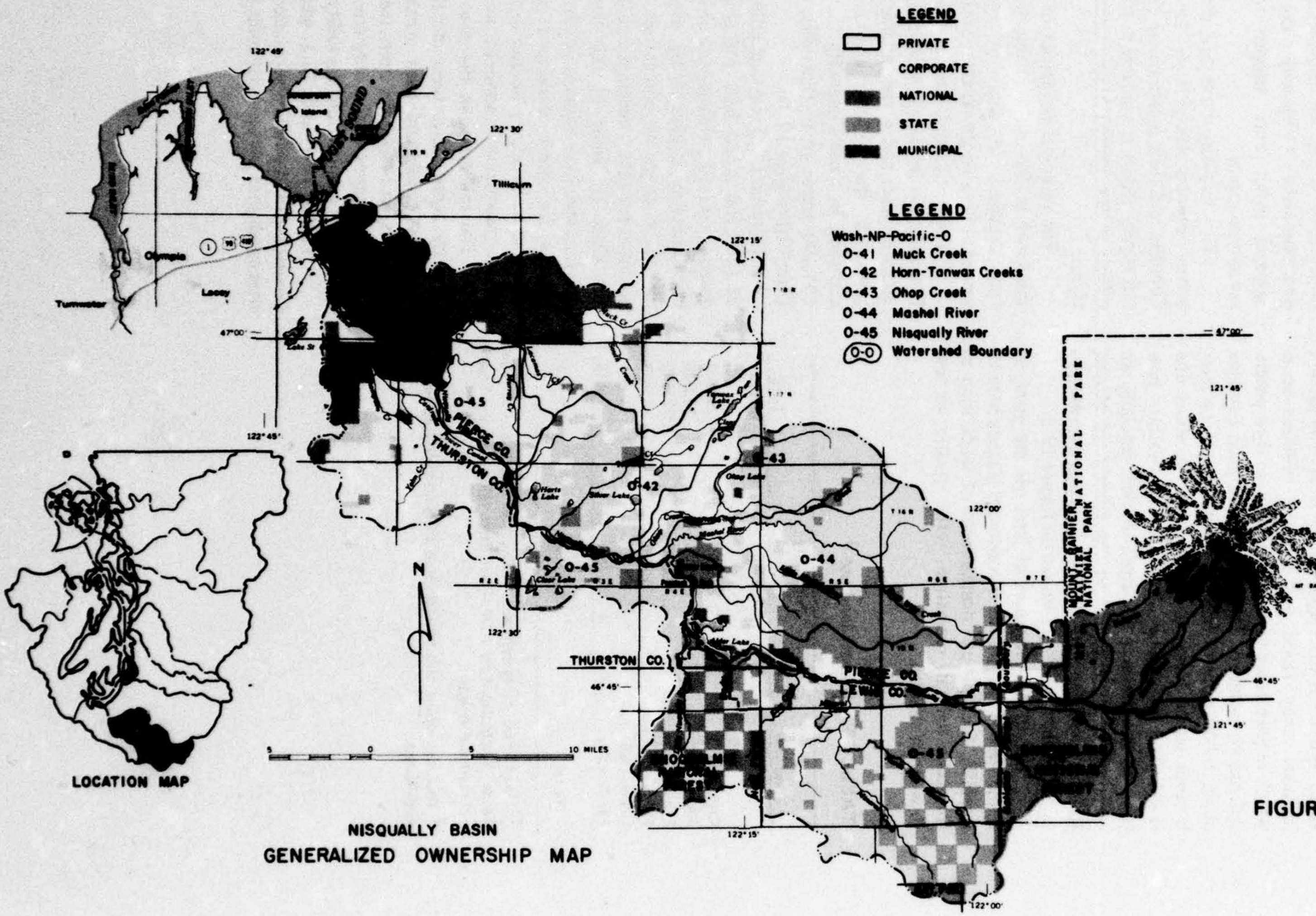
The principal properties of each soil series are tabulated in Exhibit 1, Table 6 of this Appendix. Interpretations of data for each soil series are provided in subsequent tables of the Exhibit.

The total land area of 454,800 acres in the Nisqually Basin has a medium-intensity survey on 363,500 acres and a low-intensity survey on 91,300 acres. Of the 363,500 acres, 208,100 acres are classified in Land Capability Classes II through VI, 154,200 acres are in Class VII, and 1,200 acres in Class VIII (Figure 10-3).

Lands in Land Use Capability Classes II through VI (208,100 acres) have the greatest potential for development; i.e., changed use or improved use. Land Use Capability Classes II, III, and IV may be suited for either crops or urban uses, and Class VI has potential for urban development. Most of the Class II and Class III lands in this Basin are subject to flooding and have wetness conditions which present hazards for many developed uses. Class VII is expected to be largely limited to forest use and Class VIII for recreation or aesthetic use.

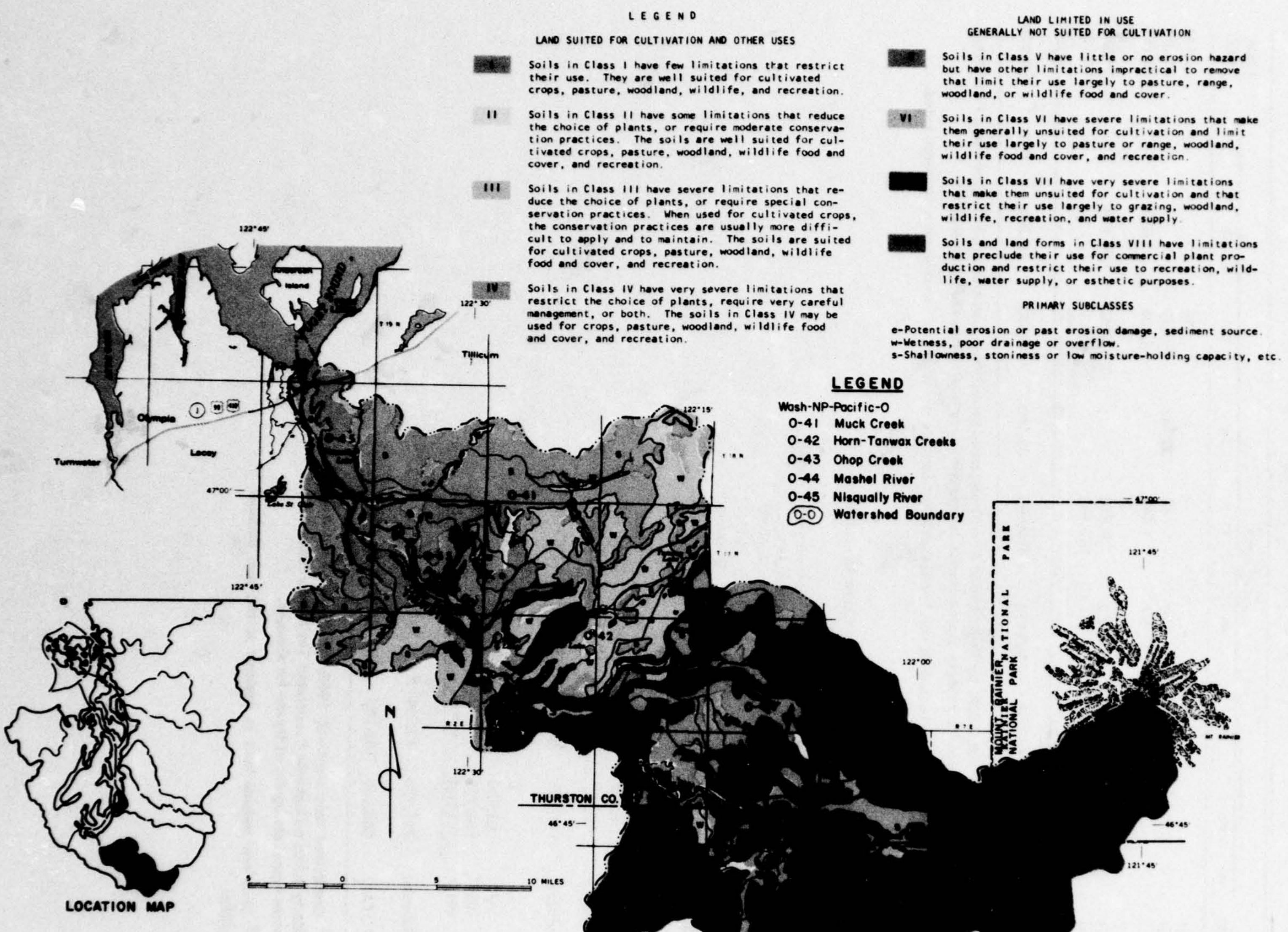
The soil types in the Area having a medium intensity survey have been classified into land use capability classes and their primary and secondary subclasses, and capability units, (see Exhibit 1, Tables 9 and 10). Lands having only reconnaissance surveys are roughly grouped into capability classes.

Tables 10-2 and 10-3 which follow give a tabulation of capability subclasses and specific wetness conditions for surveyed lands in this basin.




NISQUALLY BASIN
GENERALIZED OWNERSHIP MAP

FIGURE 10-2.




NISQUALLY BASIN
GENERALIZED LAND CAPABILITY MAP
Class and Subclass

FIGURE 10-3.

**TABLE 10-2. Land conditions by capability classes in Nisqually Basin (in acres)[1]**

| Class | Subclasses[2] e | w | s | ew | es | we | ws | se | sw | Class Total |
|---|---|---|---|---|---|---|---|---|---|---|
| II | | | 596 | | | | 5,815 | | | 6,411 |
| III | | | 1,059 | 833 | 40 | 35,143 | 14,279 | | | 51,354 |
| IV | | | 40,130 | 30,297 | 1,848 | | 8,738 | 1,930 | 847 | 83,790 |
| V | | | | | | | | | | 0 |
| VI | | | 21,202 | 9,283 | 8,628 | | 3,043 | 24,424 | | 66,580 |
| VII | | | 1,649 | | 152,153 | | 372 | | | 154,174 |
| VIII | | | | | | | 1,236 | | | 1,236 |
| TOTAL | | | 64.636 | 40,413 | 162,669 | 35,143 | 33,483 | 26,354 | 847 | 363,545 |

[1] Unadjusted measurements, 1966, for Puget Sound Area Study, based on National Cooperative Soil Survey maps. First three *figures are significant figures for acreages.* Does not include land within national forests and national parks.

[2] Letters for subclasses denote hazards or conditions that affect land use and treatment: e—erosion; w—wetness; s—soil.

**TABLE 10-3. Land with wetness condition by capability classes, Nisqually Basin (in acres)[1]**

| Land Capability Classes | All land in basin[2] Total All Land | All land in basin[2] With Wetness Condition | Cropland in basin Total Cropland (est.) | Cropland in basin Cropland With Wetness Condition (est.) |
|---|---|---|---|---|
| II | 6,411 | 5,815 | 6,090 | 5,524 |
| III | 51,354 | 50,255 | 15,262 | 14,935 |
| IV | 83,790 | 39,882 | 7,902 | 3,761 |
| Subtotal | 141,555 | 95,952 | 29,254 | 24,220 |
| V | 0 | 0 | 0 | 0 |
| VI | 66,580 | 12,326 | 0 | 0 |
| VII | 154,174 | 372 | 0 | 0 |
| VIII | 1,236 | 1,236 | 0 | 0 |
| Subtotal | 221,990 | 13,934 | 0 | 0 |
| TOTAL | 363,545 | 109,886 | 29,254 | 24,220 |

[1] Unadjusted measurements, 1966, for Puget Sound Area Study, based on National Cooperative Soil Survey maps. First three figures are signficant figures for acreages.

[2] Does not include land in national forests and national parks.

# PRESENT AND FUTURE NEEDS

## EVALUATION OF PRESENT SITUATION

In the Nisqually Basin, three broad categories of needs–protection from floodwater damage, measures for watershed protection and rehabilitation, and measures for water management–are present in varying degrees of intensity according to land use. About 29,254 acres are presently in cropland; 609,581 acres are in forest (including some areas of non-forest land); 34,008 acres are in rangeland, and 11,849 acres are in intensive land uses. According to Appendix VII, Irrigation 2,900 acres were under irrigation in 1966.

## ESTIMATED FUTURE NEEDS

Determination of needs is made on the basis of multiple-use management and the categories of floodwater damage reduction, watershed protection and rehabilitation measures, and water management contain the practices needed for development under the concept. Development needed in forestry and farming is to keep pace with other needs as the population increases and reach the level required by 2020.

Future needs are given in acres of land to be treated. Intensity or degree of practice application will increase with use. Management practices for enhancement of multiple-use objectives may require several practices on the same acre of land. A partial listing of practices used is given in Tables 2-18 and 2-19 in the Puget Sound Area section of this Appendix under Means to Satisfy Needs.

Population in the Nisqually Basin is expected to increase at a smaller rate than its neighboring basins. This projection is subject to change if an investigation, now under way, determines that a deepwater port and industrial complex on the Nisqually flats is feasible. Another possiblity, recommended by the Fish and Wildlife Committee, is for the development of various wildlife refuges in the area. Either plan would decrease the number of acres of land now in cropland.

No structural flood protective works can be economically justified before 1980. A summation of projects for the later time periods can be found in the Means to Satisfy Needs section of this Basin.

Some increase in intensive land use is expected in the lower portion of this Basin. The estimated number of acres, by land use, that will require protective and development measures by the years 1980, 2000, and 2020 are tabulated in Table 10-4. The same land area may require more than one of these practices.

**TABLE 10-4. Future needs for watershed management[1]**

| Year | Floodwater Damage[2] Reduction[3] (acres) | Watershed Protection & Rehab.[3] (acres) | Drainage Improvement[3] (acres) | Irrigation Development[4] (acres) |
|---|---|---|---|---|
| Cropland | | | | |
| 1980 | 15,986 | 53,957[5] | 3,593 | 3,500 |
| 2000 | 15,986 | 48,555[5] | 5,988 | 4,500 |
| 2020 | 15,986 | 43,652[5] | 7,984[6] | 7,715 |
| Intensive Land Use | | | | |
| 1980 | 840 | 11,849 | 11,849 | 0 |
| 2000 | 840 | 11,849 | 11,849 | 0 |
| 2020 | 840 | 11,849 | 11,849 | 0 |
| Forested Land[7] | | | | |
| 1980 | 0 | 379,675 | 0 | 0 |
| 2000 | 0 | 379,675 | 0 | 0 |
| 2020 | 0 | 379,675 | 0 | 100,242[8] |
| Unclassified Land | | | | |
| 1980 | 0 | 9,305 | 0 | 0 |
| 2000 | 0 | 14,707 | 0 | 0 |
| 2020 | 0 | 19,610 | 0 | 0 |

[1] Acreages derived by map measurements and ADP tabulation for the PS&AW study. Other potential not tabulated. Unrounded figures do not denote accuracy beyond the first three significant figures.

[2] Includes overbank flooding of main streams.

[3] Needed for full agricultural development (see Appendix V, Water-Related Land Resources, chapter 2, Agriculture).

[4] According to Appendix VII, Irrigation, there were 2,900 acres (using 6,873 acres feet of water) irrigated in 1966. Irrigation Appendix projections show 4,000 acres will be irrigated by 1980; 6,600 acres by 2000; and 10,800 acres by 2020.

[5] Includes 34,008 acres of rangeland.

[6] Does not agree with Table 10-3 due to land use changes during time lapse.

[7] Includes non-forest land commonly associated with forested areas.

[8] Potential irrigation of forests (see Appendix V, chapter 3, Forestry).

Table 10-5 shows drainage groups in the watersheds of the Nisqually Basin, with the acreage of land falling into each group. From this and other data the drainage needs for expected land uses in the Basin are derived.

TABLE 10-5. Drainage groups in Nisqually Basin [1] (in acres)[2]

| LINE | Watershed Area No.[3] | River Basins and Watersheds | 01 | 02 | 03 | 04 | 05 | 06 | 07 | 08 | 09 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Nisqually River | | | | | | | | | | | | | | | | | |
| 1 | 0.41 | Muck Creek | 664 | 0 | 1,015 | 0 | 0 | 964 | 16,975 | 39 | 1,150 | 8 | 3,448 | 1,145 | 1,385 | 0 | 0 | 3 | 26,796 |
| 2 | 0.42 | Horn-Tanwax Creeks | 793 | 0 | 905 | 10 | 0 | 307 | 16,610 | 0 | 779 | 18 | 1,040 | 628 | 762 | 10 | 0 | 190 | 22,052 |
| 3 | 0.43 | Ohop Creek | 240 | 0 | 35 | 30 | 352 | 15 | 3,440 | 0 | 5,332 | 0 | 20 | 273 | 5 | 37 | 0 | 251 | 10,030 |
| 4 | 0.44 | Machel River | 90 | 0 | 182 | 0 | 0 | 0 | 595 | 0 | 10,795 | 0 | 78 | 20 | 0 | 207 | 0 | 17 | 11,984 |
| 5 | 0.45 | Nisqually River | 5,650 | 0 | 1,226 | 141 | 180 | 1,968 | 6,503 | 8 | 10,189 | 105 | 8,291 | 768 | 1,050 | 645 | 348 | 1,952 | 39,024 |
| 6 | | Total | 7,437 | 0 | 3,363 | 181 | 532 | 3,254 | 44,123 | 47 | 28,245 | 131 | 12,877 | 2,834 | 3,202 | 899 | 348 | 2,413 | 109,886 |
| 7 | | Grand Total | 7,437 | 0 | 3,363 | 181 | 532 | 3,254 | 44,123 | 47 | 28,245 | 131 | 12,877 | 2,834 | 3,202 | 899 | 348 | 2,413 | 109,886 |

1 Descriptions of drainage groups are found in the *Means to Satisfy Needs* section of the Area report.

2 Unadjusted measurements, 1966, for Puget Sound Area Study. Tabulations by ADP. Read three significant figures.

3 See Figure 10-1 for location.

# MEANS TO SATISFY NEEDS

Population forecasts predict approximately 46,100 people in the Nisqually Basin by 2020. The means used to accomplish the levels necessary to meet the needs of this expected population consist of programs and projects for protection and development of the land and water resources of this Basin. The wise use and development of these resources can supply the spatial needs and aesthetic wants required by a growing population. The needs as developed in other appendices have been considered in this Appendix as being related to the land and water resources of the Basin.

The objectives of the plan for watershed management are to develop the Basin's resources to achieve its potential production of food and fiber as economically justified, to preserve and enhance fish, wildlife, and recreation values in accord with the Fish and Wildlife and Recreation Appendices, to provide for development of urban areas not subject to floodwater hazard, and to provide spatial needs in keeping with aesthetic qualities of the Area. These objectives will be carried out by various agencies of the Federal and State governments working in close cooperation with each other and with private sources.

## Land Use

Table 10-1 in Present Status indicates by basin the present land use. Table 10-6 summarizes by times periods the estimated future use of the land.

## Flooding

Floodwater damage must be prevented to the extent the hazard remaining does not materially exceed other risks before development is practical. Loss is limited to tolerable levels by restricting intensive use of land in hazardous areas, followed by feasible damage prevention and enhancement measures for suitable land use. Programs and projects are planned to stabilize land and related water and thus benefit most functional uses of water. Special objec-

**TABLE 10-6. Estimated future land use**

| Year | Cropland (acres) | Rangeland (acres) | Forest[1] (acres) | Urban Built-up[2] (acres) | Fresh water (acres) | Misc. uses[2] (acres) | Total (acres) |
|---|---|---|---|---|---|---|---|
| 1980 | 19,949 | 34,008 | 379,675 | 11,849 | 7,468 | 9,305 | 462,254 |
| 2000 | 14,547 | 34,008 | 379,675 | 11,849 | 7,468 | 14,707 | 462,254 |
| 2020 | 9,644 | 34,008 | 379,675 | 11,849 | 7,468 | 19,610 | 462,254 |

1 Includes alpine and non-forested areas normally associated with forest.

2 Rural non-farm is assumed to be all urban by 1980. Built-up is based on average urban density of six persons per acre.

3 Unspecified uses including land in transition usage.

tives for improvement may be selected for project purposes.

## PLAN OF DEVELOPMENT

This plan to provide for the satisfaction of the needs, as brought out in the Needs discussion, will utilize the program and project approach, as explained in the Puget Sound Area section. The plan will guide the development of the resources of the Nisqually Basin to provide for spatial and production requirements for the expected population of its service area to the year 2020. Floodwater protection and low flow augmentation projects would be beneficial for fish, wildlife, and recreation areas on the Nisqually and Mashel Rivers in particular. All projects in this Basin will be deferred until after 1980.

### Projects after 1980

Several projects will be started in the 1980-2000 and 2000-2020 time periods to remedy existing floodwater and drainage conditions and to develop lands toward their potential for continued use. Benefits and benefit-cost ratios have not been computed for projects past 1980. Total installation costs will be $3,030,000. Table 10-7 gives brief summaries of projects included in this plan:

**TABLE 10-7. Costs of projects recommended for installation after 1980**

| Watershed Area No. and Name[1] | Project Area (acres) | Struc. Meas. Installation Cost[2] (dollars) |
|---|---|---|
| 1980-2000 | | |
| 0-41 Muck Creek | 70,532 | 780,000 |
| 0-42 Horn-Tanwax Creek | 33,806 | 650,000 |
| 0-43 Ohop Creek | 27,604 | 300,000 |
| 0-45 Nisqually River | 268,644 | 1,200,000 |
| TOTAL | 400,586 | 2,930,000 |
| 2000-2020 | | |
| 0-44 Mashel River | 54,200 | 100,000 |
| TOTAL | 54,200 | 100,000 |

[1] See Figure 10-1 for location.

[2] 1967 prices

### Programs

Program measures refer to on-farm and urban on-site practices which take advantage of improvements brought about by the structural works of improvement, as well as measures for watershed protection, erosion control, and water management. These measures will include seeding of improved grasses and legumes, cover crops, cropland and urban drainage development made possible by structural works of improvement, forest management practices, and irrigation development.

Table 10-8 shows a breakdown of the various practices for each of the three time periods:

### Summary of Costs

Costs for the Nisqually Basin plan (projects costs plus program cost, rounded to the nearest hundred dollars) are expected to be $21,745,000 for the early action program; $37,670,000 for the yeras 1980-2000; and $25,006,000 for the years 2000 through 2020. Total cost of the plan will be $84,421,000. See page 2-89 et seq. for further explanation of costs.

**TABLE 10-8. Watershed management practices for protection and development, by time periods, Nisqually Basin**

| Practice | Area (acres) | Cost[1] (thousands of dollars) | |
|---|---|---|---|
| **First 15 Years** | | | |
| Technical assistance & management | 442,937[2] | | 4,537 |
| Federal, regular | | 4,537 | |
| Federal, accelerated | | 0 | |
| Installation of practices (non-Federal) | | | 17,208 |
| State & corporate management | | 7,961 | |
| Land treatment | 317,714 | 3,184 | |
| Water management | 3,593 | 689 | |
| Urban drainage | 3,981 | 5,374 | |
| Total | | | 21,745 |
| **1980-2000** | | | |
| Technical assistance & management | 442,937[2] | | 8,864 |
| Federal, regular | | 8,406 | |
| Federal, accelerated | | 458 | |
| Installation of practices (non-Federal) | | | 25,876 |
| State & corporate management | | 10,615 | |
| Land treatment | 317,714 | * 4,245 | |
| Water management | 2,395 | * 579 | |
| Urban drainage | 7,731 | * 10,437 | |
| Total | | | 34,740 |
| **2000-2020** | | | |
| Technical assistance & management | 442,937[2] | | 8,767 |
| Federal, regular | | 8,652 | |
| Federal, accelerated | | 115 | |
| Installation of practices (non-Federal) | | | 16,139 |
| State & corporate management | | 10,615 | |
| Land treatment | 317,714 | * 4,245 | |
| Water management | 3,215 | * 959 | |
| Urban drainage | | * 320 | |
| Total | | | 24,906 |

[1] Base: 1967 prices, except items asterisked which are 1967 adjusted normalized prices. See page 2-89 et seq. for further explanation of costs.

[2] Total acres in Basin involved in program measures.

# DESCHUTES BASIN

The Deschutes Basin includes parts of two counties. Approximately 90 percent of the basin lies in eastern Thurston County, with the remaining 10 percent in northeastern Lewis County.

## PRESENT STATUS

In 1963 the population was 50,100, and projections of population indicate that by 1980 it will be 52,900; by 2000, 72,800; and by the year 2020 will reach 100,400. Present population density, based on urban and rural non-farm lands, is 1.79 people per acre.

Forestry and farming are the main users of land in the Basin. Livestock raising is the most common and valuable farm industry. Dairying, berry growing, and poultry raising also play an important part in the economic welfare of the Basin. Total value of farm production is almost $5 million annually.

Forestry, including logging, lumbering, and the production of related products, is probably the major industry in the Basin. Forested lands comprise about 127,000 acres, including non-forested areas normally associated with forest.

Logging, lumbering, and the production of forest products, have always been the Basin's economic mainstay. Today, other commodities such as metalcraft, can manufacturing, boat building, cold storage, and meat packing, are of marked importance and give the area a diversified commercial base. The port of Olympia comprises over 72 acres and is equipped to handle any cargo from both ocean vessels and local water freight. Since Olympia is the State Capitol, State government plays an important part in the Basin's economy. Mining, farming, and fishing while extremely important in the past, have become industries of minor importance throughout the Basin.

The artificially created salmon production from the Deschutes River contributes significantly to the commercial and sport fisheries of Puget Sound, Strait of Juan de Fuca and Pacific Ocean coastal waters. The marine waters of the southern Puget Sound Region produce a good portion of the large Pacific oysters and very small, choice Olympia oysters grown within Puget Sound.

In the Deschutes Basin, habitat is available to support sizeable quantities of big game, upland game, and fur-bearing animals. The numerous lakes and ponds indicate a high waterfowl potential. This potential is not fully realized however, due to a lack of fertile soil and accompanying diversified farming activity.

The waters and shoreline of Puget Sound is the most significant recreation feature of the Basin. There are also numerous lakes and streams affording recreation opportunities.

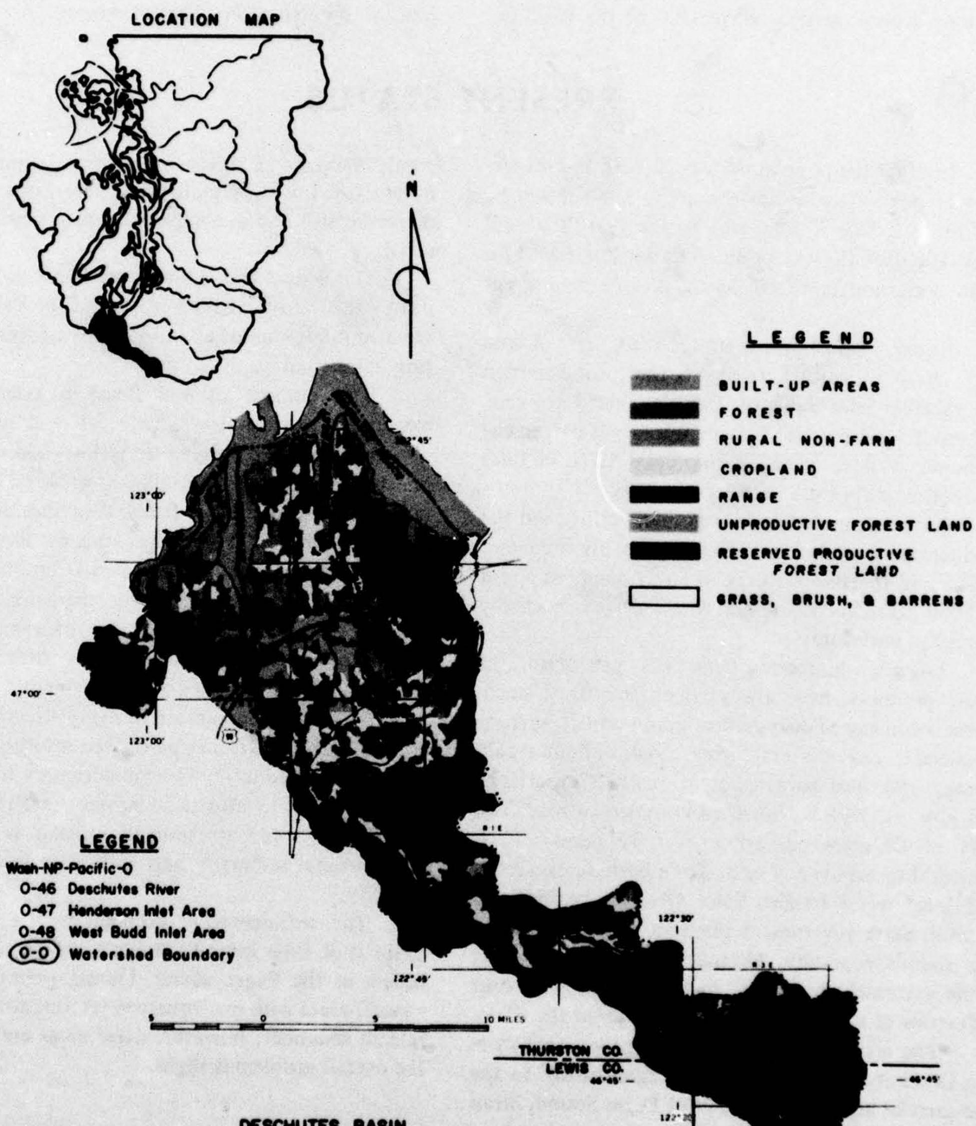
The climate of the Basin is conducive to extremes of streamflows. Late fall and winter frequently produce damaging floodflows and conversely midsummer drought produces low flow conditions which are detrimental to fish and wildlife, recreation, and to sanitation within the streams. Potential for development of streams and rivers is limited in many respects unless low flows can be augmented to some degree by structural measures and management practices. Low flow characteristics for streams in the Basin are given in Appendix II, Hydrology.

The present condition of many stream and river channels in this Basin is partly the result of nearly a century of exploitation by man with only the last few years devoted to efforts to protect and rehabilitate the environment. Streambank erosion is severe in areas where sediment and debris reduce channel capacity.

The sedimentation problem in the Desuchtes Basin is of little magnitude when compared to other basins in the Puget sound. During periods of high runoff, areas with inadequate vegetative cover tend to release sediment, however, these areas are small and the overall problem is slight.

### PRESENT LAND USE

The Deschutes River flows into the Puget Sound at Budd Inlet. It drains an area of 287 square miles and has no major tributaries. The Deschutes Basin provides the third smallest valley system in the Puget Sound Area. The system includes many flood




DESCHUTES BASIN
GENERALIZED LAND USE MAP

FIGURE 10a-1.

and drainage problem areas which require corrective measures before their potential may be attained. The lower flood plain contains about 3,000 acres of level or gently undulating river bottom land. Above the city of Tenino, the Basin is composed of rough mountainous valleys with turbulent streams. Most of the farmland sits above the flood plain on glaciated terraces (see Figure 10a-1). The ownership distribution of the Basin's lands are shown on Figure 10a-2.

The broad categories of land use are given in Table 10a-1 which follows. No attempt is made here to quantify multiple-use management of lands such as for game habitat, recreation, water quality, or low flow augmentation.

**TABLE 10a-1. Present land use[1]**

| Land Use | Deschutes Basin (acres) | Total (acres) |
|---|---|---|
| Cropland | 16,248 | 16,248 |
| Rangeland | 9,480 | 9,480 |
| Forest[2] | 127,123 | 127,123 |
| Rural non-farm | 13,541 | 13,541 |
| Urban built-up | 14,416 | 14,416 |
| Fresh Water | 2,597 | 2,597 |
| Total | 183,405 | 183,405 |

[1] *Unadjusted measurements, 1966, for Puget Sound Area Study. Tabulations by ADP. First three figures are significant figures for acreages.*

[2] *Includes non-forested lands normally associated with forest areas.*

## SOILS

A medium-intensity soil survey is available for most lands outside the national forest boundaries. Lands within the national forests were mapped from a reconnaissance-type survey.

The mapping units are discussed in the soil survey reports for Thurston and Lewis Counties and their locations are shown on maps. The soil survey report is available in libraries and in local offices of the United States Department of Agriculture.

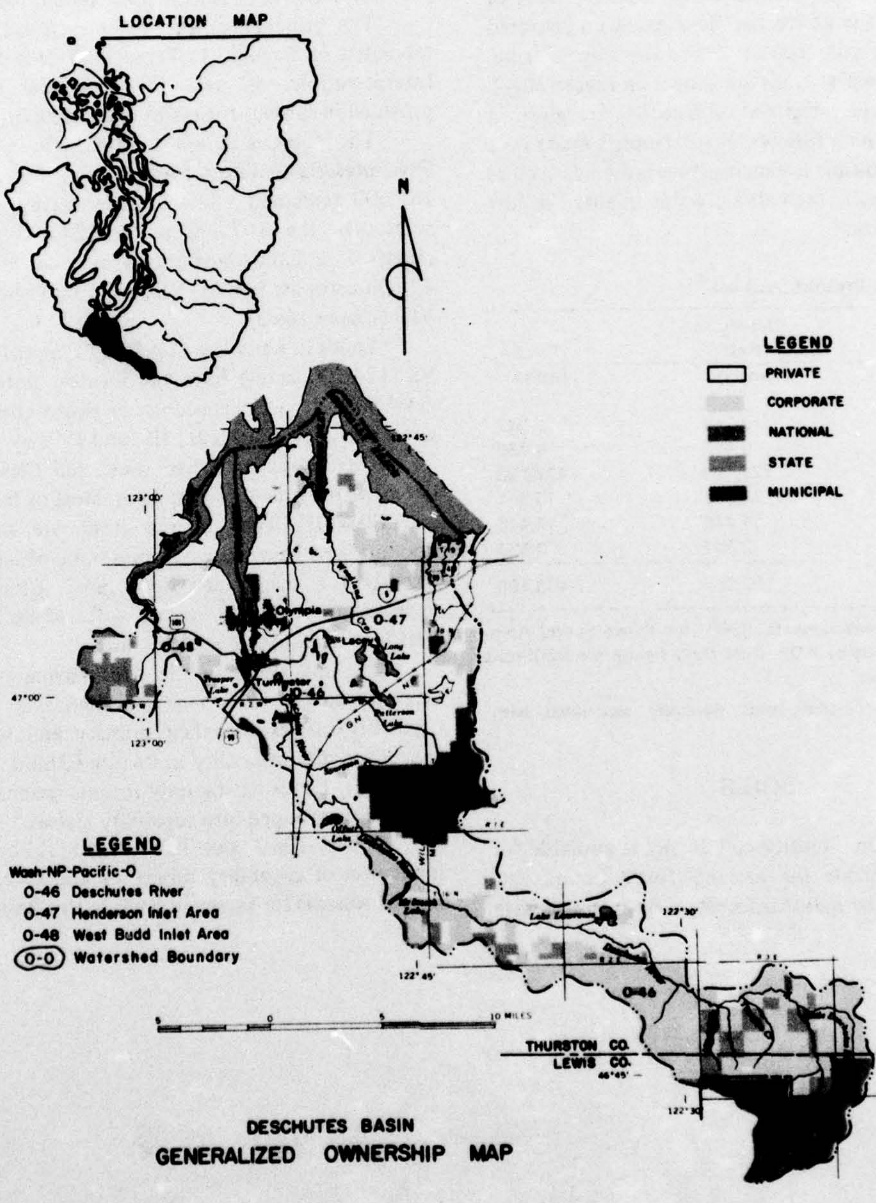
The principal properties of each soil series are tabulated in Exhibit 1, Table 6 of this Appendix. Interpretations of data for each soil series are provided in subsequent tables of the Exhibit.

The total land are of 180,800 acres in the Deschutes Basin has a medium-intensity survey on 167,600 acres and a low-intensity survey on 13,200 acres. Of the 167,600 acres, 124,500 acres are classified in Land Capability Classes II through VI, 42,100 acres are in Class VII, and 1,000 acres in Class VIII (Figure 10a-3).

Lands in Land Use Capability Classes II through VI (124,500 acres) have the greatest potential for development; i.e., changed use or improved use. Land Use Capability Classes II, III, and IV may be suited for either crops or urban uses, and Class VI has potential for urban development. Most of the Class II and Class III lands in this Basin are subject to flooding and have wetness conditions which present hazards for many developed uses. Class VII is expected to be largely limited to forest use and Class VIII for recreation or aesthetic use.

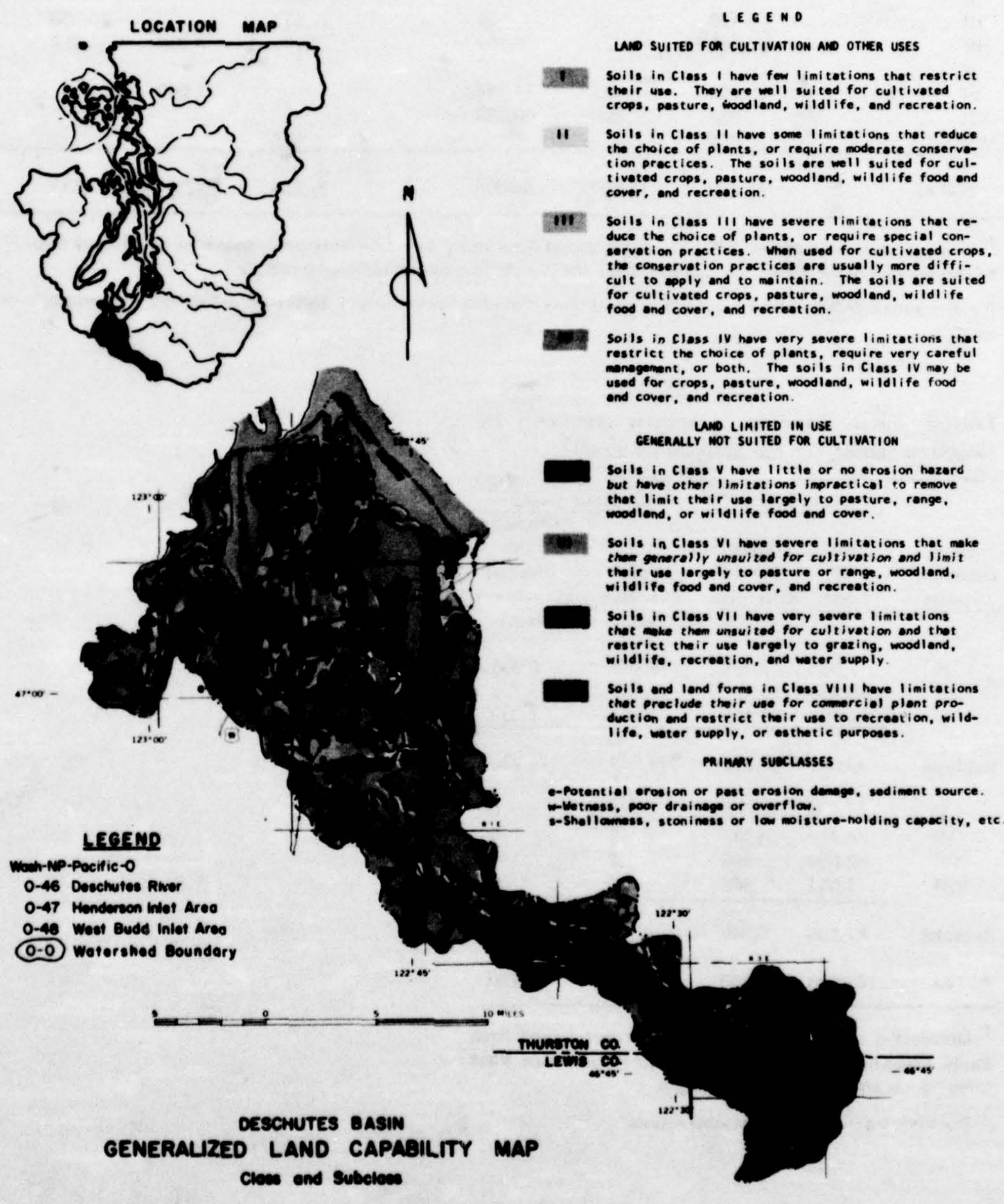
The soil types in the Area having a medium intensity survey have been classified into land use capability classes and their primary and secondary subclasses, and capability units (see Exhibit 1, Tables 9 and 10). Lands having only reconnaissance surveys are roughly grouped into capability classes.

Tables 10a-2 and 10a-3 which follow give a tabulation of capability subclasses and specific wetness conditions for surveyed lands in this Basin.




DESCHUTES BASIN
GENERALIZED OWNERSHIP MAP

FIGURE 10a-2.




DESCHUTES BASIN
GENERALIZED LAND CAPABILITY MAP
Class and Subclass

FIGURE 10a-3.

TABLE 10a-2. Land conditions by capability classes in Deschutes Basin (in acres)[1]

| Class | Subclasses[2] | | | | | | | | | Class Total |
|---|---|---|---|---|---|---|---|---|---|---|
| | e | w | s | ew | es | we | ws | se | sw | |
| II | | | | | | | 7,363 | | | 7,363 |
| III | | | 7,128 | | 55 | | 10,917 | | 60 | 18,160 |
| IV | | | 24,560 | 13,927 | 5,752 | | 2,791 | 4,038 | 3,457 | 54,525 |
| V | | | | | | | | | | 0 |
| VI | | | 13,821 | 3,585 | 14,344 | | | 12,669 | | 44,419 |
| VII | | | 938 | 995 | 40,163 | | | | | 42,096 |
| VIII | | | 350 | | | | 665 | | | 1,015 |
| TOTAL | | | 46,797 | 18,507 | 60,314 | | 21,736 | 16,707 | 3,517 | 167,578 |

1 Unadjusted measurements, 1966, for Puget Sound Area Study, based on National Cooperative Soil Survey maps. First three figures are significant figures for acreages. Does not include land within national forests.

2 Letters for subclasses denote hazards or conditions that affect land use and treatment: e—erosion; w—wetness: s—soil.

TABLE 10a-3. Land with wetness condition by capability classes, Deschutes Basin (in acres)[1]

| Land Capability Classes | All land in basin[2] | | Cropland in basin | |
|---|---|---|---|---|
| | Total All Land | With Wetness Condition | Total Cropland (est.) | Cropland With Wetness Condition (est.) |
| II | 7,363 | 7,363 | 6,995 | 6,995 |
| III | 18,160 | 10,977 | 5,552 | 3,356 |
| IV | 54,525 | 20,175 | 3,701 | 1,369 |
| Subtotal | 80,048 | 38,515 | 16,248 | 11,720 |
| V | 0 | 0 | 0 | 0 |
| VI | 44,419 | 3,585 | 0 | 0 |
| VII | 42,096 | 995 | 0 | 0 |
| VIII | 1,015 | 665 | 0 | 0 |
| Subtotal | 87,530 | 5,245 | 0 | 0 |
| TOTAL | 167,578 | 43,760 | 16,248 | 11,720 |

1 Unadjusted measurements, 1966, for Puget Sound Area Study, based on National Cooperative Soil Survey maps. First three figures are significant for acreages.

2 Does not include land in national forests.

# PRESENT AND FUTURE NEEDS

## EVALUATION OF PRESENT SITUATION

Present trends in the Deschutes Basin reveal that the intensive land use is filling in and around the city of Olympia and several of the smaller outlying communities. A large part of this is primarily new residential development to serve the increasing numbers of persons employed by State government in Olympia.

Measures for floodwater damage reduction, watershed protection and rehabilitation, and water management are present in varying degrees of intensity according to land use. About 16,248 acres are presently in cropland; 127,123 acres are in forest (including some non-forest areas); 9,480 acres are classified as range; and 27,957 acres are in more intensive uses. Appendix VII, Irrigation, states that 2,700 acres were under irrigation in 1966.

## ESTIMATED FUTURE NEEDS

Determination of needs is made on the basis of multiple-use management and the categories of floodwater damage reduction, watershed protection and rehabilitation measures, and water management contain the practices needed for development under the concept. Development needed in forestry and farming is to keep pace with other needs as the population increases and reach the level required by 2020.

Future needs are given in acres of land to be treated. Intensity or degree of practice application will increase with use. Management practices for enhancement of multiple-use objectives may require several practices on the same acres of land. A partial listing of practices used is given in Tables 2-18 and 2-19 in the Puget Sound Area section of this Appendix under Means to Satisfy Needs.

As in the Nisqually Basin, no early action projects are planned. A summation of projects for the later time periods can be found in the Means to Satisfy Needs section of this Basin.

As urban development increases, the existing land use is likely to undergo extensive change in the Deschutes Basin. The estimated number of acres, according to land use, that will require protective and development measures by the years 1980, 2000, and 2020 are tabulated in Table 10a-4. The same land area may require more than one of these practices.

**TABLE 10a-4. Future needs for watershed management[1]**

| Year | Floodwater Damage[2] Reduction[3] (acres) | Watershed Protection & Rehab.[3] (acres) | Drainage Improvement[3] (acres) | Irrigation Development[3][4] (acres) |
|---|---|---|---|---|
| Cropland | | | | |
| 1980 | 11,802 | 21,282[5] | 1,738 | 3,000 |
| 2000 | 11,802 | 17,559[5] | 2,897 | 3,500 |
| 2020 | 11,802 | 14,836[5] | 3,863[6] | 4,285 |
| Intensive Land Use | | | | |
| 1980 | 1,720 | 27,957 | 27,957 | 0 |
| 2000 | 1,720 | 27,957 | 27,957 | 0 |
| 2020 | 1,720 | 27,957 | 27,957 | 0 |
| Forested Land[7] | | | | |
| 1980 | 0 | 127,123 | 0 | 0 |
| 2000 | 0 | 127,123 | 0 | 0 |
| 2020 | 0 | 127,123 | 0 | 26,358[8] |
| Unclassified Land | | | | |
| 1980 | 0 | 4,446 | 0 | 0 |
| 2000 | 0 | 8,169 | 0 | 0 |
| 2020 | 0 | 10,892 | 0 | 0 |

1 Acreages derived by map measurements and ADP tabulation for the PS&AW Study. Other potential not tabulated. Unrounded figures do not denote accuracey beyond the first three significant figures.

2 Includes overbank flooding of main stteams.

3 Needed for full agricultural development (see Appendix V, Water-Related Land Resources, chapter 2, Agriculture).

4 According to Appendix VII, Irrigation, there were 2,700 acres (using 6,399 acres feet of water) irrigated in 1966. Irrigation Appendix projections show 3,800 acres irrigated by 1980, 6,200 by 2000, and 10,000 acres by 2020.

5 Includes 9,480 acres of rangeland.

6 Does not agree with Table 10a-3 due to land use changes during time lapse.

7 Includes non-forested land commonly associated with forested areas.

8 Potential irrigation of forests (see Appendix V, chapter 3, Forestry).

Table 10a-5 shows drainage groups in the watersheds of the Deschutes Basin, with the acreage of land falling into each group. From this and other data the drainage needs for expected land uses in the Basin are derived.

**TABLE 10a-5. Drainage groups in Deschutes Basin[1] (in acres)[2]**

| LINE | Watershed Area No[3] | River Basins and Watersheds | 01 | 02 | 03 | 04 | 05 | 06 | 07 | 08 | 09 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Deschutes River | | | | | | | | | | | | | | | | | |
| 1 | 0-46 | Deschutes River | 2,144 | 0 | 1,123 | 3 | 973 | 612 | 820 | 0 | 828 | 0 | 3,865 | 306 | 399 | 369 | 0 | 735 | 12,177 |
| 2 | | Total | 2,144 | 0 | 1,123 | 3 | 973 | 612 | 820 | 0 | 828 | 0 | 3,865 | 306 | 399 | 369 | 0 | 735 | 12,177 |
| | | Puget Sound Drainages | | | | | | | | | | | | | | | | | |
| 3 | 0-47 | Henderson Inlet Area | 1,996 | 0 | 2,190 | 0 | 0 | 11,447 | 0 | 15 | 1,723 | 0 | 4,651 | 701 | 411 | 0 | 0 | 445 | 23,579 |
| 4 | 0-48 | West Budd Inlet Area | 820 | 0 | 567 | 0 | 97 | 1,982 | 0 | 31 | 450 | 0 | 3,685 | 76 | 254 | 15 | 0 | 27 | 8,004 |
| 5 | | Total | 2,816 | 0 | 2,757 | 0 | 97 | 13,429 | 0 | 46 | 2,173 | 0 | 8,336 | 777 | 665 | 15 | 0 | 472 | 31,583 |
| 6 | | Grand Total | 4,960 | 0 | 3,880 | 3 | 1,070 | 14,041 | 820 | 46 | 3,001 | 0 | 12,201 | 1,083 | 1,064 | 384 | 0 | 1,207 | 43,760 |

[1] Descriptions of drainage groups are found in the Means to Satisfy Needs section of the Area report.

[2] Unadjusted measurements, 1966, for Puget Sound Area Study. Tabulations by ADP. Read three signficiant figures.

[3] See Figure 10a-1 for location.

# MEANS TO SATISFY NEEDS

Projections indicate that by the year 2020 population in this Basin will be 100,400. Means set forth to achieve the levels necessary to meet the needs of this expected population consist of programs and projects for protection and development of the land and water resources of the Deschutes Basin. The wise use and development of these resources can supply the spatial needs and aesthetic wants of an expanding population. The needs as developed in other appendices have been considered herein as being related to the land and water resources of this Basin.

The objectives of the plan for watershed management are to develop the Basin's resources to achieve its potential production of food and fiber as economically justified, to preserve and enhance fish, wildlife, and recreation values in accord with the Fish and Wildlife, and Recreation Appendices, to provide for development of urban areas not subject to floodwater hazard, and to provide spatial needs in keeping with aesthetic qualities of the Area. These objectives will be carried out by varous agencies of the Federal and State governments working in close cooperation with each other and with private sources.

## Land Use

Table 10a-1 in Present Status indicates by basin the present land use. Table 10a-6 summarizes by time periods the estimated future use of the land.

## Flooding

Floodwater damage must be prevented to the extent the hazard remaining does not materially exceed other risks before development becomes practical. Loss is limited to tolerable values by restricting development on hazardous areas.

Watersheds require varied combinations and intensities of management according to the capability of the land and its use. Programs are planned to stabilize land and related water and thus benefit most functional uses of water. Special objectives for improvement may be selected for project purposes.

**TABLE 10a-6. Estimated future land use**

| Year | Crop-land (acres) | Range-land (acres) | Forest[1] (acres) | Urban Built-up[2] (acres) | Fresh water (acres) | Misc. uses[3] (acres) | Total (acres) |
|---|---|---|---|---|---|---|---|
| 1980 | 11,802 | 9,480 | 127,123 | 27,957 | 2,597 | 4,446 | 183,405 |
| 2000 | 8,079 | 9,480 | 127,123 | 27,957 | 2,597 | 8,169 | 183,405 |
| 2020 | 5,356 | 9,480 | 127,123 | 27,957 | 2,597 | 10,892 | 183,405 |

[1] Includes non-forested land normally associated with forest.

[2] Rural non-farm is assumed to be all urban by 1980. Built-up is based on average urban density of six persons per acre.

[3] Unspecified uses including land in transitional usage.

## PLAN OF DEVELOPMENT

The objectives of the plan are to develop the Basin's resources to achieve its potential production of food and fiver as economically justified, and to provide for development of urban areas not subject to floodwater hazard.

This plan to provide for the satisfaction of needs will utilize the program and project approach, and will guide the development of the resources of the Deschutes Basin to provide for spatial and production requirements for the expected population of its service area to the year 2020. Floodwater protection and low flow augmentation projects would be beneficial for fish, wildlife, and recreation areas on the Deschutes River. All projects in this Basin, will be deferred until after 1980.

### Projects after 1980

Several projects will be initiated in the 1980-2000 time period to remedy existing floodwater and drainage problems and to develop lands toward their potential for continued use. Benefits and benefit-cost ratios have not been computed for projects past 1980. *Table 10a-7 gives brief summaries of* projects included in this plan:

**TABLE 10a-7. Cost of projects recommended for installation after 1980**

| Watershed Area No. and Name[1] | Project Area (acres) | Struc. Meas. Installation Cost[2] (dollars) |
|---|---|---|
| 0-46 Deschutes River | 96,048 | 550,000 |
| 0-47 Henderson Inlet | 62,504 | 700,000 |
| 0-48 West Budd Inlet | 22,256 | 160,000 |
| Total | 180,808 | 1,410,000 |

1 *See Figure 10a-1 for location.*

2 1967 prices.

### Programs

Program measures refer to on-farm and urban on-site practices which take advantage of improvements made possible by the structural works of improvement, as well as measures for watershed protection, erosion control, and water management. These measures will include seeding of improved grasses and legumes, cover crops, cropland and urban drainage development made possible by structural works of improvement, forest management practices, and irrigation development.

Table 10a-8 shows a breakdown of the various practices for each of the three time periods.

### Summary of Costs

Costs for the Deschutes Basin plan (project costs plus program costs, rounded to the nearest thousand dollars) are expected to be $18,965,000 for early action program; $34,801,000 for the years 1980-2000; and $9,600,000 for the yeras 2000 through 2020. Total costs of the plan will be $63,366,000. See page 2-89 et seq. for further explanation of costs.

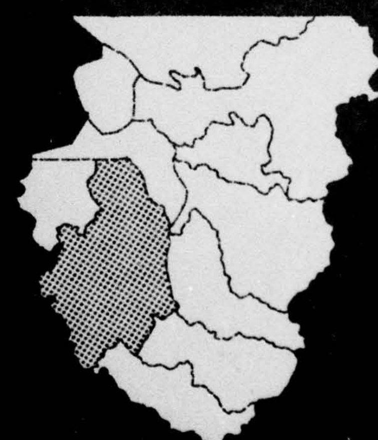
**TABLE 10a-8. Watershed management practices for protection and development, by time periods, Deschutes Basin**

| Practice | Area (acres) | Cost[1] (thousands of dollars) | |
|---|---|---|---|
| <u>First 15 Years</u> | | | |
| Technical assistance and management | 152,851[2] | | 1,317 |
| Federal, regular | | 1,317 | |
| Federal, accelerated | | 0 | |
| Installation of practices (non-Federal) | | | 17,648 |
| State & corporate management | | 3,096 | |
| Land treatment | 130,141 | 1,572 | |
| Water management | 1,738 | 441 | |
| Urban drainage | 9,288 | 12,539 | |
| Total | | | 18,965 |
| <u>1980-2000</u> | | | |
| Technical assistance & management | 152,851[2] | | 2,462 |
| Federal, regular | | 2,118 | |
| Federal, accelerated | | 344 | |
| Installation of practices (non-Federal) | | | 30,929 |
| State & corporate management | | 4,128 | |
| Land treatment | 130,141 | * 2,096 | |
| Water management | 1,159 | * 354 | |
| Urban drainage | 18,038 | *24,351 | |
| Total | | | 33,391 |
| <u>2000-2020</u> | | | |
| Technical assistance & management | 152,851[2] | | 2,155 |
| Federal, regular | | 2,155 | |
| Federal, accelerated | | 0 | |
| Installation of practices (non-Federal) | | | 7,445 |
| State & corporate management | | 4,128 | |
| Land treatment | 130,141 | * 2,096 | |
| Water management | 966 | * 369 | |
| Urban drainage | 631 | * 852 | |
| Total | | | 9,600 |

[1] Base: 1967 prices, except items asterisked which are 1967 adjusted normalized prices. See page 2-89 et seq. for further explanation of costs.

[2] Total acres in Basin involved in program measures.

# West Sound Basins



# WEST SOUND BASINS

The West Sound Basins include all of Kitsap County and parts of Clallam, Jefferson, Mason, Thurston, Pierce and King Counties. The Basins include some islands and the land on the peninsula, with the exception of the Elwha-Dungeness Basins.

The western part of the Basins are mountainous, as the boundary is the crest of the coast range and the Olympic range of mountains. The remainder of the Basins show evidence of major glaciation and is gently rolling, with somewhat poorly developed drainage in some areas.

## PRESENT STATUS

In 1963 the population was 114,900, and projections indicate that by 1980 the population will be 161,400; by 2000, 253,400; and by the year 2020 will reach 399,600. Present population density, based on urban and rural non-farm lands, is 1.08 people per acre.[1]

Farming is important to the Basins with a substantial dairy industry and a large grape industry as the main dollar volume items. Total value of farm production in the West Sound Basins is over $4.5 million annually. Forest products are likely to continue to be the largest basic industry in the Basins.

Forest products industries are of prime importance to the Basins Paper mills are located at Port Townsend, and several large sawmills are within the area. Canneries for fish also are located here. Bremerton Naval Shipyard, the largest service installation, and other smaller government installations are located within the Basins.

Salmon production from the many rivers and streams of the West Sound Basins contribute heavily to the commercial and sport fisheries of Puget Sound, Hood Canal, Strait of Juan de Fuca and the Pacific Ocean. The major portion of the shellfish production, oysters and clams, are located within Hood Canal and the southern portion of the Basins. The abundance of fisheries resources within the Basins. provide a substantial portion of the income and economy.

The varied species of upland game are the most widely distributed of the major game groups. Native species utilize the remaining native habitat and introduce exotics have been established in the area directed to agricultural use. Several varieties of big game inhabit the timbered areas and a wide variety of native fur-bearing animals exist at lower elevations. Diving ducks are numerous in the Basins but the more popular hunting species of waterfowl are less abundant.

The West Sound Basins have the most extensive salt water recreation resources of any basin or island groups within the Study Area. The central and eastern portions are completely interlaced with sheltered waters which are augmented by attractive islands, bays, and fresh water lakes. In the western portion, the beautiful Olympic Mountains seem to rise from the clear waters of the Hood Canal. Numerous streams, plus Lake Cushman, provide further attractions within the mountainous reaches.

The climate of the Basins is conducive to extremes of streamflows. Late fall and winter frequently produce damaging floodflows and conversely midsummer drought produces low flow conditions which are detrimental to fish, and wildlife, recreation, and to sanitation within the streams. Potential for development of streams and rivers is limited in many respects unless low flows can be augmented to some degree by structural measures and management practices. Low flows characteristics for streams in the Basins are given in Appendix III, Hydrology.

The present condition of many stream and river channels in these Basins is partly the result of nearly a century of exploitation by man with only the last few years devoted to efforts to protect and rehabilitate the environment. Streambank erosion is severe in areas where sediment and debris reduce channel capacity.

Appreciable movement of bed materials occurs on the Skokomish River during periods of high runoff, but in the other principal rivers the movement of bedload is less pronounced, and occurs mostly in lower reaches. Smaller streams are generally unable to transport large quantities of bed materials. Some of the eroded sediments are deposited in lakes and reservoirs.

[1] Population figures for these Basins were based on preliminary economic data prepared in 1967 and may be slightly lower than the same data in other appendices.

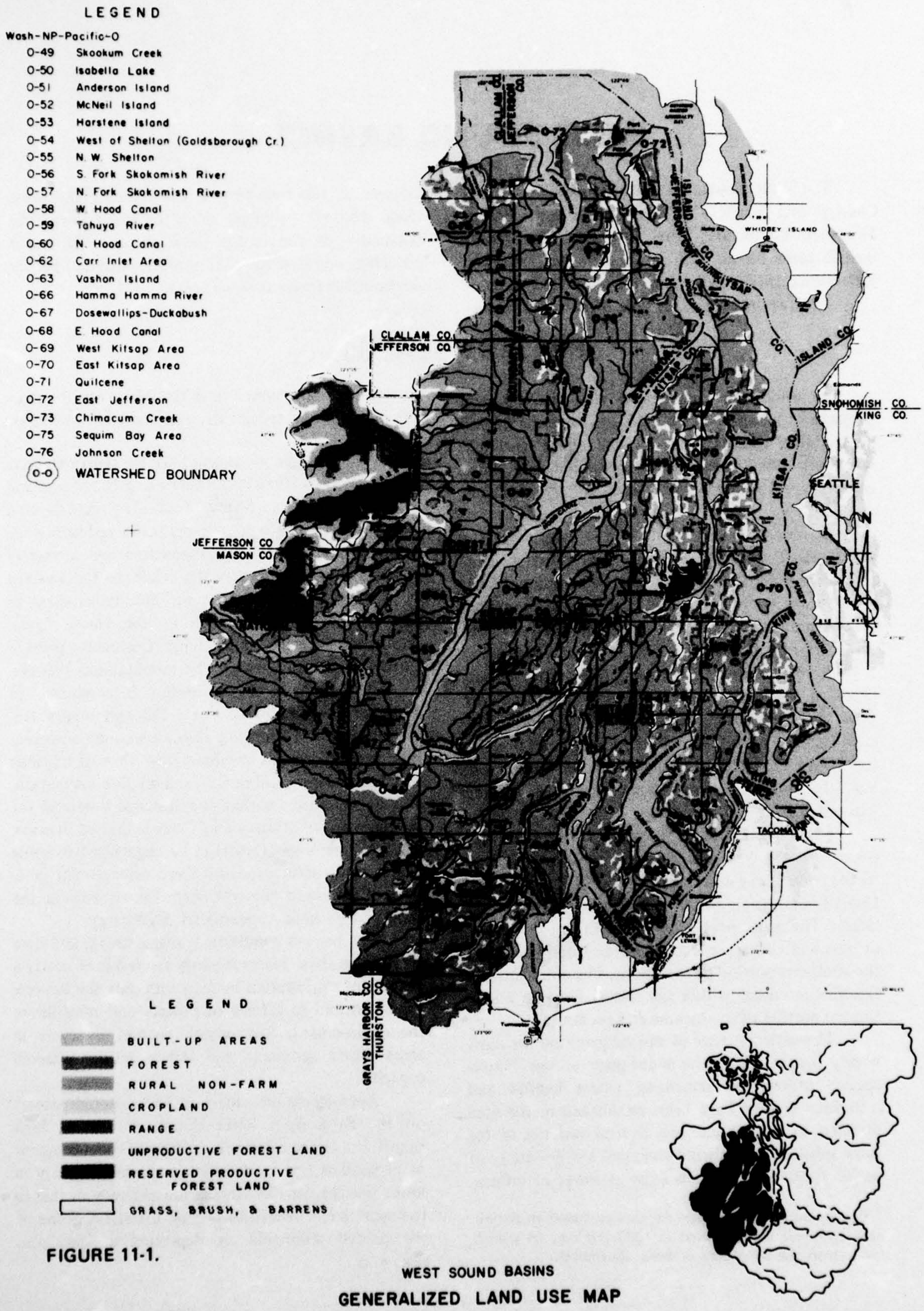



FIGURE 11-1.

WEST SOUND BASINS

GENERALIZED LAND USE MAP

## PRESENT LAND USE

The Skokomish River is the largest river system in the Basins. It drains an area of 244 square miles. Total drainage of the Basins is 2,022 square miles. Smaller rivers within the Basins are the Quilcene, Doeswallips, Duckabush, and Hamma Hamma Rivers, all of which originate in rough mountainous country and empty into the Hood Canal area of Puget Sound. The Kitsap peninsula and the islands within the Basins are drained by small streams with lower gradients. The Basins include many flood and drainage problem areas which require corrective measures to attain their potential. Presently, about 46,000 acres are devoted to farming, with a potential total of about 120,000 acres of Class II and III lands which could be used for this purposed (see Figure 11-1). The ownership distribution of the Basin's lands are shown on Figure 11-2.

The broad categories of land use are given in Table 11-1. No attempt is made here to quantify mulitple-use management of lands such as for game habitat, recreation, water quality, or low flow augmentation.

**TABLE 11-1. Present land use by sub-basin[1]**

| Land Use | Skokomish River Basin (acres) | Coastal Drainages (acres) | Total (acres) |
|---|---|---|---|
| Cropland | 1,970 | 44,245 | 46,215 |
| Rangeland | 80 | 5,057 | 5,137 |
| Forest[2] | 148,806 | 974,860 | 1,123,666 |
| Rural non-farm | 530 | 63,678 | 64,208 |
| Urban built-up | 376 | 41,785 | 42,161 |
| Fresh water | 4,668 | 7,938 | 12,606 |
| Total | 156,430 | 1,137,563 | 1,293,993 |

[1] Unadjusted measurements, 1966, for Puget Sound Area Study. Tabulations by ADP. First three figures are significant figures for acreages.

[2] Includes non-forested areas normally associated with forest.

## SOILS

A medium-intensity soil survey is available for most lands outside the national forest and national park boundaries. Lands within the national forests and parks were mapped from a reconnaissance-type survey.

The mapping units are discussed in the soil survey reports for Kitsap, Clallam, Jefferson, Mason, Thurston, Pierce and King Counties and their locations are shown on maps. The soil survey report is available in libraries and in local offices of the United States Department of Agriculture.

The principal properties of each soil series are tabulated in Exhibit 1, Table 6 of this Appendix. Interpretations of data for each soil series are provided in subsequent tables of the Exhibit.

The total land area of 1,281,400 acres in the West Sound Basins has a medium-intensity survey on 915,500 acres and a low-intensity survey on 365,900 acres. Of the 915,500 acres, 772,300 acres are classified in land Capability Classes II through VI, 131,300 acres are in Class VII, and 12,000 acres in Class VIII (Figure 11-3).

Lands in Land Use Capability Classes II through VI (772,300 acres) have the greatest potential for development; i.e., changed use or improved use. Land Use Capability Classes II, III, and IV may be suited for either crops or urban uses, and Class VI has potential for urban development. Most of the Class II and Class III lands in these Basins are subject to flooding and have wetness conditions which present hazards for many developed uses. Class VII is expected to be largely limited to forest use and Class VIII for recreation or aesthetic use.

The soil types of the Area having a medium-intensity survey have been classified into land use capability classes and their primary and secondary subclasses, and capability units (see Exhibit 1, Tables 9 and 10). Lands having only reconnaissance surveys are roughly grouped into capability classes.

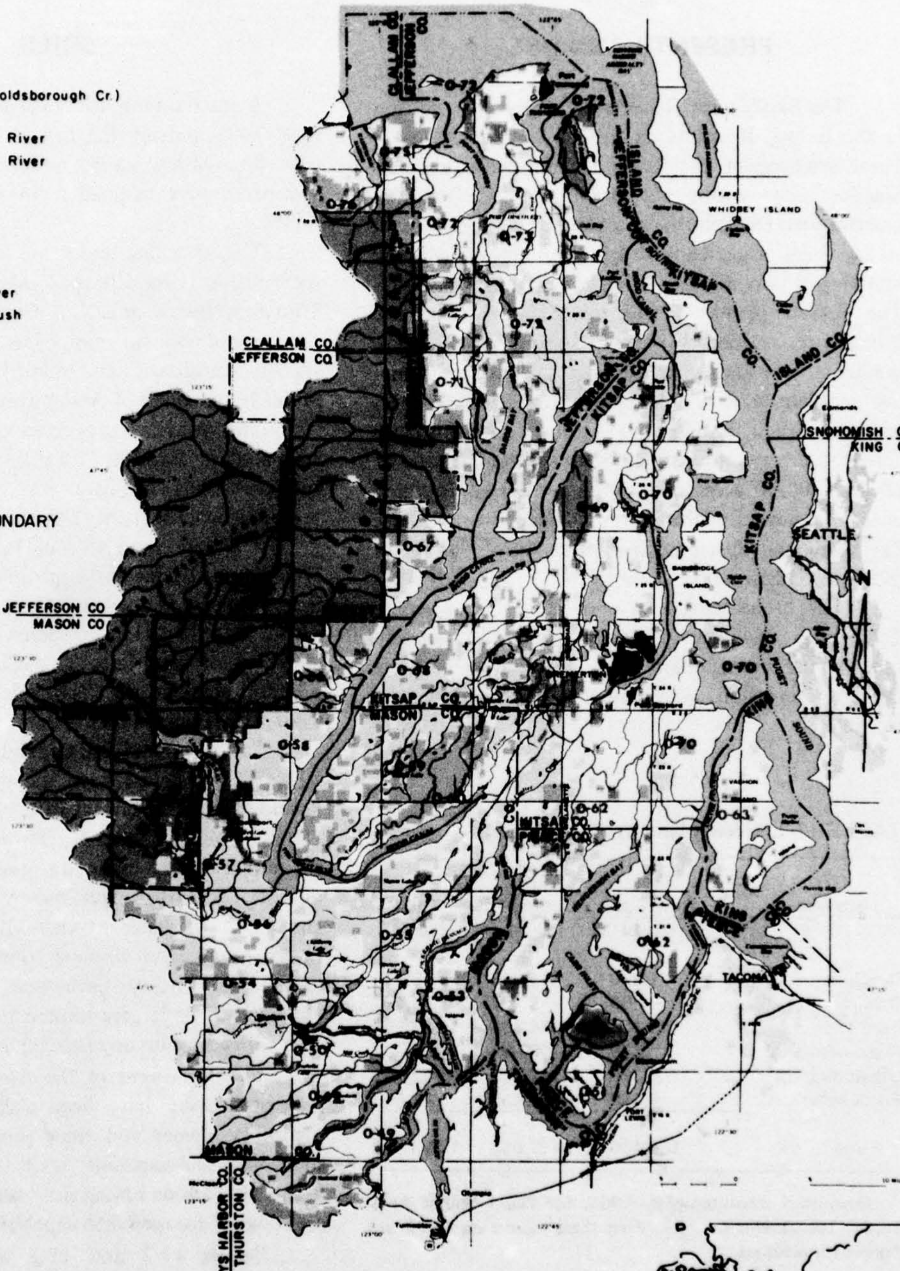
Tables 11-2 and 11-3 which follow give a tabulation of capability subclasses and specific wetness conditions for surveyed lands in these Basins.

## LEGEND

Wash-NP-Pacific-O

- 0-49 Skookum Creek
- 0-50 Isabella Lake
- 0-51 Anderson Island
- 0-52 McNeil Island
- 0-53 Harstene Island
- 0-54 West of Shelton (Goldsborough Cr.)
- 0-55 N. W. Shelton
- 0-56 S. Fork Skokomish River
- 0-57 N. Fork Skokomish River
- 0-58 W. Hood Canal
- 0-59 Tahuya River
- 0-60 N. Hood Canal
- 0-62 Carr Inlet Area
- 0-63 Vashon Island
- 0-66 Hamma Hamma River
- 0-67 Dosewallips-Duckabush
- 0-68 E. Hood Canal
- 0-69 West Kitsap Area
- 0-70 East Kitsap Area
- 0-71 Quilcene
- 0-72 East Jefferson
- 0-73 Chimacum Creek
- 0-75 Sequim Bay Area
- 0-76 Johnson Creek

(0-0) WATERSHED BOUNDARY




## LEGEND

- PRIVATE
- CORPORATE
- NATIONAL
- STATE
- MUNICIPAL

**FIGURE 11-2.**

**WEST SOUND BASINS**

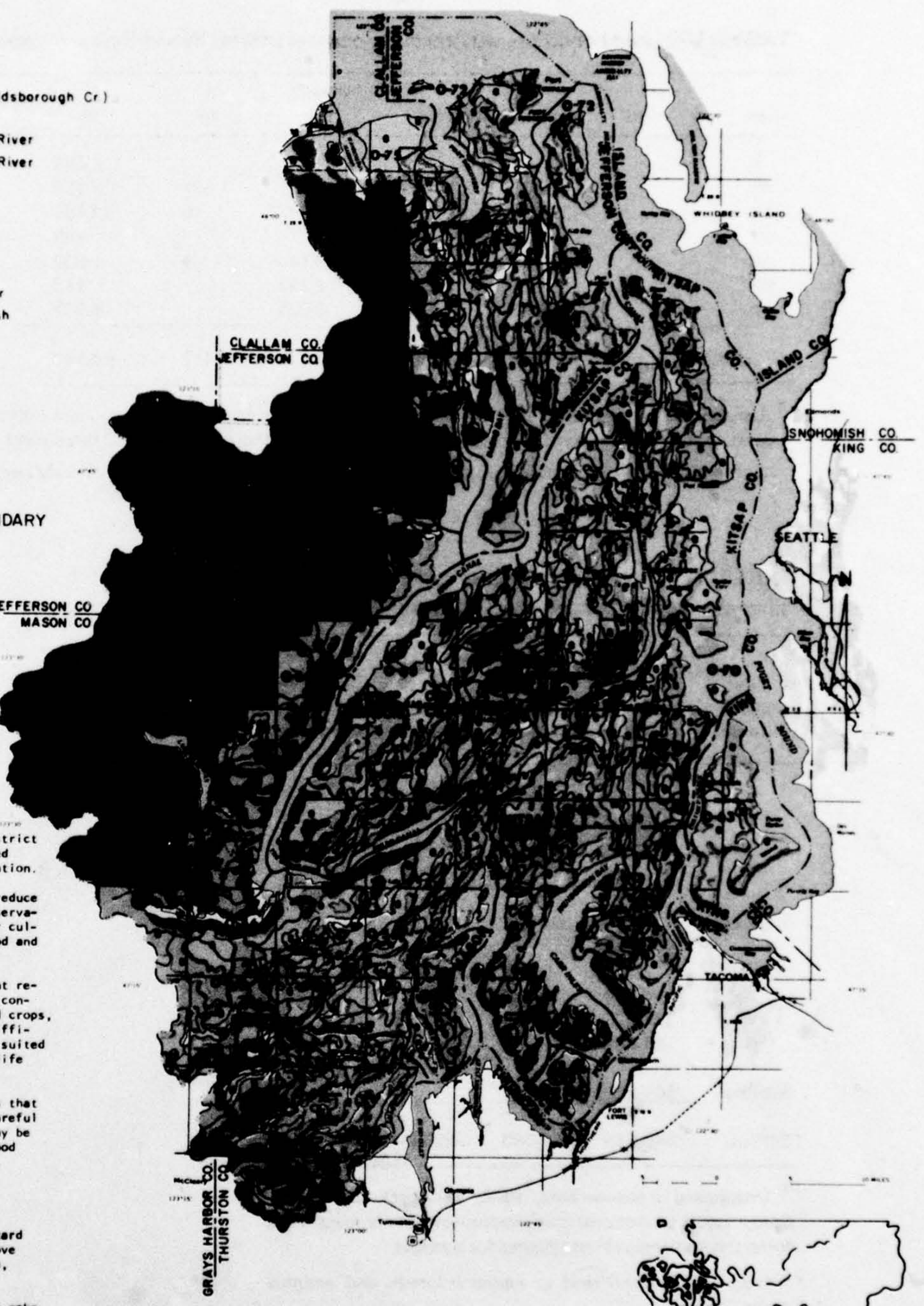
**GENERALIZED OWNERSHIP MAP**

LOCATION MAP

## LEGEND

Wash-NP-Pacific-O

- 0-49 Skookum Creek
- 0-50 Isabella Lake
- 0-51 Anderson Island
- 0-52 McNeil Island
- 0-53 Harstene Island
- 0-54 West of Shelton (Goldsborough Cr.)
- 0-55 N. W. Shelton
- 0-56 S. Fork Skokomish River
- 0-57 N. Fork Skokomish River
- 0-58 W. Hood Canal
- 0-59 Tahuya River
- 0-60 N. Hood Canal
- 0-62 Carr Inlet Area
- 0-63 Vashon Island
- 0-66 Hamma Hamma River
- 0-67 Dosewallips-Duckabush
- 0-68 E. Hood Canal
- 0-69 West Kitsap Area
- 0-70 East Kitsap Area
- 0-71 Quilcene
- 0-72 East Jefferson
- 0-73 Chimacum Creek
- 0-75 Sequim Bay Area
- 0-76 Johnson Creek
- (0-0) WATERSHED BOUNDARY




### LEGEND

**LAND SUITED FOR CULTIVATION AND OTHER USES**

I — Soils in Class I have few limitations that restrict their use. They are well suited for cultivated crops, pasture, woodland, wildlife, and recreation.

II — Soils in Class II have some limitations that reduce the choice of plants, or require moderate conservation practices. The soils are well suited for cultivated crops, pasture, woodland, wildlife food and cover, and recreation.

III — Soils in Class III have severe limitations that reduce the choice of plants, or require special conservation practices. When used for cultivated crops, the conservation practices are usually more difficult to apply and to maintain. The soils are suited for cultivated crops, pasture, woodland, wildlife food and cover, and recreation.

IV — Soils in Class IV have very severe limitations that restrict the choice of plants, require very careful management, or both. The soils in Class IV may be used for crops, pasture, woodland, wildlife food and cover, and recreation.

**LAND LIMITED IN USE**
**GENERALLY NOT SUITED FOR CULTIVATION**

V — Soils in Class V have little or no erosion hazard but have other limitations impractical to remove that limit their use largely to pasture, range, woodland, or wildlife food and cover.

VI — Soils in Class VI have severe limitations that make them generally unsuited for cultivation and limit their use largely to pasture or range, woodland, wildlife food and cover, and recreation.

Soils in Class VII have very severe limitations that make them unsuited for cultivation and that restrict their use largely to grazing, woodland, wildlife, recreation, and water supply.

Soils and land forms in Class VIII have limitations that preclude their use for commercial plant production and restrict their use to recreation, wildlife, water supply, or esthetic purposes.

**PRIMARY SUBCLASSES**

e-Potential erosion or past erosion damage, sediment source.
w-Wetness, poor drainage or overflow.
s-Shallowness, stoniness or low moisture-holding capacity, etc.

LOCATION MAP

WEST SOUND BASINS
**GENERALIZED LAND CAPABILITY MAP**

**FIGURE 11-3.**

**TABLE 11-2. Land conditions by capability classes in West Sound Basins (in acres)[1]**

| Class | e | w | s | ew | es | we | ws | se | sw | Class Total |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Subclasses[2] | | | | | |
| II | | | | | | | 18,485 | | 1,665 | 20,150 |
| III | | | 830 | 71,099 | 3,471 | 2,437 | 26,257 | | 1,132 | 105,226 |
| IV | | | 3,382 | 198,150 | 25,947 | 10 | 13,465 | 7,932 | 33,631 | 282,517 |
| V | | | | | | | 138 | | | 138 |
| VI | | | 93,683 | 71,498 | 113,743 | | 1,932 | 83,372 | | 364,228 |
| VII | | | | 18,962 | 112,132 | | 182 | | | 131,276 |
| VIII | | | 809 | 3,158 | 2,031 | | 5,982 | | | 11,980 |
| TOTAL | | | 98,704 | 362,867 | 257,324 | 2,447 | 66,441 | 91,304 | 36,428 | 915,515 |

[1] Unadjusted measurements, 1966, for Puget Sound Area Study, based on National Cooperative Soil Survey maps. First three figures are significant figures for acreages. Does not include land within national forests and national parks.

[2] Letters for subclasses denote hazards or conditions that affect land use and treatment: e—erosion; w—wetness; s—soil.

**TABLE 11-3. Land with wetness condition by capability classes, West Sound Basins (in acres)[1]**

| Land Capability Classes | All land in basin[2]: Total All Land | All land in basin[2]: With Wetness Condition | Cropland in basins: Total Cropland (est.) | Cropland in basins: Cropland With Wetness Condition (est.) |
|---|---|---|---|---|
| II | 20,150 | 20,150 | 16,120 | 16,120 |
| III | 105,226 | 100,925 | 20,057 | 17,040 |
| IV | 282,517 | 245,256 | 10,038 | 8,644 |
| Subtotal | 407,893 | 366,331 | 46,215 | 41,804 |
| V | 138 | 138 | 0 | 0 |
| VI | 364,228 | 73,430 | 0 | 0 |
| VII | 131,276 | 19,144 | 0 | 0 |
| VIII | 11,980 | 9,140 | 0 | 0 |
| Subtotal | 507,622 | 101,852 | 0 | 0 |
| TOTAL | 915,515 | 468,183 | 46,215 | 41,804 |

[1] Unadjusted measurements, 1966, for Puget Sound Area Study, based on National Cooperative Soil Survey maps. First three figures are significant figures for acreages.

[2] Does not include land in national forests and national parks.

# PRESENT AND FUTURE NEEDS

## EVALUATION OF PRESENT SITUATION

In the West Sound Basins three broad categories of needs–protection from floodwater damage, measures for watershed protection and rehabilitation, and measures for water management–are present in varying degrees of intensity according to land use. About 46,215 acres are devoted to cropland use at the present time; 1,123,666 acres are in forest (including some non-forested land); 5,137 acres are in rangeland; and 106,369 acres are in intensive uses. According to Appendix VII, Irrigation, 1,200 acres were under irrigation in 1966.

## ESTIMATED FUTURE NEEDS

Determination of needs is made on the basis of multiple-use management and the categories of floodwater damage reduction, watershed protection and rehabilitation measures, and water management, contain the practices needed for development under the concept. Development needed in forestry and farming is to keep pace with other needs as the population increases and reach the level required by 2020.

Future needs are given in acres of land to be treated. Intensity or degree of practice application will increase with use. Management practices for enhancement of multiple-use objectives may require several practices on the same acre of land. A partial listing of practices used is given in Tables 2-18 and 2-19 in the Puget Sound area section of this Appendix under Means to Satisfy Needs.

The projected rapid rise in population, with its requirements for space, recreation, and other land and water needs, makes it necessary to initiate an early action program of development to avoid costly misue of the land resource. An obvious need in these Basins is for improved floodwater damage reduction on the Skokomish flood plain and some of the smaller rivers, as described in Appendix XII, Flood Control, and for flood prevention and drainage facilities to be installed on two watersheds considered to be in need of improvements to accommodate orderly development of the Basins. Details of these to accommodate orderly development of the Basins. Details of these early action projects are found in the Means to Satisfy Needs section.

The potential growth area for the West Sound Basins is located in Kitsap County, along the shores and on the islands of Puget Sound and the Gig Harbor peninsula in Pierce County. In addition there is a small potential area located in Mason County around and to the south of the city of Shelton. The estimated number of acres, according to land use, that will require protective and development measures by the years 1980, 2000, and 2020 are shown in Table 11-4. The same land area may require more than one of these practices.

**TABLE 11-4. Future needs for watershed management[1]**

| Year | Floodwater Damage[2] Reduction[3] | Watershed Protection & Rehab.[3] | Drainage Improvement[3] | Irrigation Development[3][4] |
|---|---|---|---|---|
| | (acres) | (acres) | (acres) | (acres) |
| Cropland | | | | |
| 1980 | 43,107 | 48,244[5] | 17,138 | 5,000 |
| 2000 | 43,107 | 46,690[5] | 28,563 | 7,000 |
| 2020 | 43,107 | 45,137[5] | 38,084[6] | 15,000 |
| Intensive Land Use | | | | |
| 1980 | 1,430 | 106,369 | 106,369 | 0 |
| 2000 | 1,430 | 106,369 | 106,369 | 0 |
| 2020 | 1,430 | 106,369 | 106,369 | 0 |
| Forest Land[7] | | | | |
| 1980 | 0 | 1,123,666 | 0 | 0 |
| 2000 | 0 | 1,123,666 | 0 | 0 |
| 2020 | 0 | 1,123,666 | 0 | 171,400[8] |
| Unclassified Land | | | | |
| 1980 | 0 | 3,108 | 0 | 0 |
| 2000 | 0 | 4,662 | 0 | 0 |
| 2020 | 0 | 6,215 | 0 | 0 |

1 Acreages derived by map measurements and ADP tabulation for the PS&AW study. Other potential not tabulated. Unrounded figures do not denote accuracy beyond the first three significant figures.

2 Includes overbank flooding of main streams.

3 Needed for full agricultural development (see Appendix V, Water-Related Land Resources, chapter 2, Agriculture).

4 According to Appendix VII, Irrigation, there were 1,200 acres (using 3,060 acre of feet water ) irrigated in 1966. Irrigation Appendix projections show 1,600 acres irrigated by 1980, 2,100 acres by 2000, and 2,600 acres by 2020.

5 Includes 5,137 acres of rangeland.

6 Does not agree with Table 11-3 due to land use changes during time lapse.

7 Includes non-forested land commonly associated with forested areas.

8 Potential irrigation of forests (see Appendix V, chapter 3, Forestry.

Tables 11-5 shows drainage groups in the watersheds of the West Sound Basins, with the acreage of land falling into each group. From this and other data the drainage needs for expected land uses in the Basins are derived.

**TABLE 11-5. Drainage groups in West Sound Basins[1] (in acres)[2]**

| LINE | Watershed Area No.[3] | River Basins and Watershed | 01 | 02 | 03 | 04 | 05 | 06 | 07 | 08 | 09 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Skokomish River | | | | | | | | | | | | | | | | | |
| 1 | 0-56 | S. Fork Skokomish R. | 4,390 | 0 | 879 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3,062 | 128 | 0 | 0 | 0 | 940 | 9,399 |
| 2 | 0-57 | N. Fork Skokomish R. | 450 | 0 | 146 | 0 | 0 | 10 | 0 | 0 | 0 | 0 | 0 | 57 | 0 | 0 | 0 | 167 | 830 |
| 3 | | Total | 4,840 | 0 | 1,025 | 0 | 0 | 10 | 0 | 0 | 0 | 0 | 3,062 | 185 | 0 | 0 | 0 | 1,107 | 10,229 |
| | | Puget Sound Drainages | | | | | | | | | | | | | | | | | |
| 4 | 0-49 | Skookum Creek | 1,019 | 0 | 474 | 0 | 481 | 7,533 | 0 | 21 | 1,308 | 15 | 5,610 | 149 | 45 | 30 | 0 | 116 | 16,801 |
| 5 | 0-50 | Isabella | 333 | 0 | 411 | 0 | 181 | 3,930 | 0 | 0 | 516 | 0 | 1,313 | 60 | 17 | 0 | 0 | 0 | 6,761 |
| 6 | 0-51 | Anderson Island | 5 | 0 | 0 | 0 | 0 | 0 | 196 | 0 | 65 | 686 | 1,454 | 55 | 0 | 657 | 0 | 0 | 3,118 |
| 7 | 0-52 | McNeil Island | 0 | 0 | 56 | 0 | 0 | 7 | 322 | 0 | 250 | 0 | 2,386 | 0 | 0 | 0 | 0 | 0 | 3,030 |
| 8 | 0-53 | Hartstene Island | 40 | 0 | 66 | 0 | 0 | 526 | 0 | 0 | 217 | 104 | 3,399 | 36 | 0 | 0 | 0 | 19 | 4,407 |
| 9 | 0-54 | Goldsborough Creek | 405 | 0 | 894 | 0 | 55 | 2,032 | 0 | 164 | 392 | 0 | 0 | 215 | 544 | 0 | 0 | 145 | 4,846 |
| 10 | 0-56 | N. W. Shelton | 297 | 0 | 2,957 | 0 | 0 | 5,036 | 0 | 50 | 715 | 511 | 59,930 | 561 | 81 | 0 | 0 | 283 | 70,420 |
| 11 | 0-58 | West Hood Canal | 285 | 0 | 530 | 0 | 0 | 17 | 0 | 5 | 22 | 0 | 5 | 117 | 0 | 0 | 0 | 210 | 1,191 |
| 12 | 0-59 | Tahuya River | 705 | 0 | 191 | 0 | 0 | 940 | 70 | 0 | 0 | 0 | 16,981 | 112 | 0 | 0 | 0 | 228 | 19,207 |
| 13 | 0-60 | North Hood Canal | 292 | 0 | 670 | 0 | 0 | 1,300 | 0 | 202 | 10 | 0 | 12,367 | 183 | 10 | 0 | 0 | 307 | 15,341 |
| 14 | 0-62 | Carr Inlet Area | 154 | 0 | 749 | 0 | 0 | 2,271 | 2,185 | 420 | 812 | 618 | 28,102 | 170 | 217 | 40 | 0 | 56 | 35,794 |
| 15 | 0-63 | Vashon Island | 143 | 0 | 33 | 0 | 0 | 336 | 0 | 0 | 0 | 0 | 16,516 | 5 | 0 | 17 | 0 | 0 | 17,050 |
| 16 | 0-66 | Hamma Hamma River | 130 | 0 | 0 | 0 | 0 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 69 | 224 |
| 17 | 0-67 | Dosewallips-Duckabush | 720 | 18 | 35 | 0 | 0 | 90 | 0 | 0 | 5 | 0 | 3,481 | 0 | 0 | 0 | 0 | 132 | 4,481 |
| 18 | 0-68 | East Hood Canal | 356 | 0 | 419 | 0 | 0 | 1,796 | 0 | 50 | 22 | 0 | 26,957 | 99 | 0 | 0 | 0 | 95 | 29,794 |
| 19 | 0-69 | West Kitsap Area | 85 | 0 | 1,432 | 0 | 0 | 8,182 | 1,082 | 1,391 | 0 | 0 | 34,647 | 0 | 0 | 0 | 0 | 25 | 46,844 |
| 20 | 0-70 | East Kitsap Area | 861 | 0 | 2,511 | 0 | 0 | 6,324 | 753 | 2,424 | 0 | 0 | 39,228 | 0 | 0 | 0 | 0 | 256 | 52,357 |
| 21 | 0-71 | Quilcene | 1,152 | 2 | 305 | 186 | 0 | 1,726 | 0 | 113 | 162 | 0 | 7,493 | 141 | 0 | 205 | 0 | 165 | 11,650 |
| 22 | 0-72 | East Jefferson | 2,037 | 105 | 1,281 | 11 | 118 | 10,629 | 0 | 651 | 994 | 0 | 57,130 | 789 | 158 | 343 | 0 | 1,074 | 75,320 |
| 23 | 0-73 | Chimacum | 201 | 42 | 468 | 23 | 5 | 3,335 | 0 | 446 | 486 | 0 | 11,293 | 1,455 | 39 | 61 | 0 | 0 | 17,844 |
| 24 | 0-75 | Sequim Bay Area | 139 | 0 | 69 | 0 | 0 | 167 | 0 | 0 | 173 | 0 | 9,988 | 0 | 26 | 0 | 0 | 19 | 10,561 |
| 25 | 0-76 | Johnson Creek | 160 | 0 | 104 | 0 | 0 | 588 | 1,304 | 0 | 366 | 0 | 8,259 | 0 | 0 | 67 | 0 | 75 | 10,913 |
| 26 | | Total | 9,519 | 167 | 13,644 | 220 | 840 | 56,789 | 5,912 | 5,937 | 6,505 | 1,934 | 346,509 | 4,147 | 1,137 | 1,420 | 0 | 3,274 | 457,954 |
| 27 | | Grand Total | 14,359 | 167 | 14,669 | 220 | 840 | 56,799 | 5,912 | 5,937 | 6,505 | 1,934 | 349,571 | 4,332 | 1,137 | 1,420 | 0 | 4,381 | 468,183 |

[1] Descriptions of drainage groups are found in the Means to Satisfy Needs section of the Area report.

[2] Unadjusted measurements, 1966, for Puget Sound Area Study. Tabulations by ADP. Read three signficant figures.

[3] See Figure 11-1 for location.

# MEANS TO SATISFY NEEDS

Population in the West Sound Basins is expected to reach 432,700 people by 2020. To satisfy the needs of this many people, a plan consisting of programs and projects for protection and development of the land and water resources has been devised. The wise use and development of these resources can supply the spatial needs and aesthetic wants of the growing population. The needs, as developed in other appendices, have been considered in this Appendix as related to the land and water resources of the Basins.

The objectives of the plan for watershed management are to develop the Basins' resources to achieve their potential production of food and fiber as economically justified, to preserve and enhance fish, wildlife, and recreation values in accord with the Fish and Wildlife, and Recreation Appendices, to provide for development of urban areas not subject to floodwater hazard, and to provide spatial needs in keeping with aesthetic qualities of the Area. These objectives will be carried out by various agencies of the Federal and State governments, working in close cooperation with each other and with private sources.

## Land Use

Table 11-1 in Present Status indicates by sub-basins the present land use. Table 11-6 summarizes by time periods the estimated future use of the land.

## Flooding

Floodwater damage must be prevented to the extent the hazard remaining does not materially exceed other risks before development is practical. Loss is limited to tolerable levels by restricting intensive use of land in hazardous areas, followed by feasible damage prevention and enhancement meaures for suitable land use.

**TABLE 11-6. Estimated future land use**

| Year | Crop-land (acres) | Range-land (acres) | Forest[1] (acres) | Urban Built-up[2] (acres) | Fresh water (acres) | Misc. uses[3] (acres | Total (acres) |
|---|---|---|---|---|---|---|---|
| 1980 | 43,107 | 5,137 | 1,123,666 | 106,369 | 12,606 | 3,108 | 1,293,993 |
| 2000 | 41,553 | 5,137 | 1,123,666 | 106,369 | 12,606 | 4,662 | 1,293,993 |
| 2020 | 40,000 | 5,137 | 1,123,666 | 106,369 | 12,606 | 6,215 | 1,293,993 |

1 Includes non-forested land normally associated with forest.

2 Rural non-farm is assumed to be all urban by 1980. Built-up is based on average urban density of six persons per acre.

3 Unspecified uses including land in transitional usage.

Watershed require varied combinations and intensities of management according to capability and use. Programs and projects are planned to stabilize land and related water and thus benefit most functional uses of water. Special objectives for improvement may be selected for project purposes.

## PLAN OF DEVELOPMENT

This plan to provide for the needs as brought out in the Needs discussion will utilize the program and project approach, as explained in the Puget Sound Area section. The plan will guide the development of the resources of the West Sound Basins to provide for spatial and production requirements for the expected population of its service area to the year 2020. Flood control and low flow augmentation projects have a potential for enhancing fish, wildlife, and recreation benefits on the Skokomish, Little Quilcene, Dosewallips, Duckabush, Hamma Hamma, and Union Rivers as well as numerous creeks.

### Early Action Projects

Projects will be initiated prior to 1980 to remedy existing floodwater and drainage problems and to develop lands toward their potential for continued use. Table 11-7 describes projects in the early action plan.

**Goldsborough Creek Watershed Area 0-54, Figure 11-1** is the principal stream of this area, which is approximately 60 square miles. The watershed is 90 percent forest land and the economy is based on forest products. The terrain is low mountains. The Coffee Creek valley is the principal agricultural area. Shelton is the major city and the industry of the area is centered there.

The project is designed for flood prevention of agricultural and urban areas, and drainage of agricultural lands. The area contains 38,501 acres of which 907 acres are cropland, 34,599 acres are forest, 2,906 acres rural non-farm and urban, and 89 acres miscellaneous uses.

The works of improvement will consist of 5 miles of improved and stabilized channel, and one floodwater retarding structure for flood control.

**TABLE 11-7. Costs and benefited areas, early action projects recommended for installation by 1980**

| Watershed Area No. and Name[1] | Project Area (acres) | Project Structural Measures Cost[2] (dollars) | Flood-water Protection (acres) | Drainage Improvement (acres) |
|---|---|---|---|---|
| 0-54 Goldsborough Creek | 38,501 | 779,000 | 3,388 | 261 |
| 0-73 Chimacum Creek | 22,326 | 300,000 | 3,375 | 2,717 |
| Total | 60,827 | 1,079,000 | 6,763 | 2,978 |

1 See Figure 11-1 for location.

2 1967 prices

Installation cost is estimated to be $779,165, of which the Federal share is $503,335, and the local share is $275,830. Benefits from damage reduction and drainage will provide a benefit-cost ratio of 1.2 to 1. To achieve benefits made possible by the structural works and other management during a 15-year period, local interests will install necessary land treatment measures for erosion control and flood management, costing approximately $64,282, drainage measures expected to cost $61,808, and forest protection and management practices costing $746,300 for a total of $871,662. The total cost of installing the structural measures and the land treatment measures is $1,650,827.

**Chimacum Creek Watershed Area 0-73, Figure 11-1** flows to the north and outlets into Port Townsend Bay near the city of Port Townsend. The flood plain is used principally for cultivated agriculture while the major portion of the upland is covered with dense forest of fir, alder and native brush.

Watershed water problems are mainly due to inadequate channels to carry flood and drainage water. Water control structures are necessary to stabilize the water table in the areas of organic soil.

The project is designed for flood prevention of agricultural and urban areas, and drainage of agricultural lands. The area contains 22,326 acres, of which 4,257 acres are cropland, 16,981 acres are forest, 862 acres rural non-farm and urban, and 226 acres miscellaneous uses.

The works of improvement will consist of 16 miles of improved and stabilized channel, eight water control structures, and one debris basin for the detention and control of stream sediment.

Installation cost is estimated to be $299,890, of which the Federal share is $232,650, and the local share is $67,240. Benefits from damage reduction and drainage will provide a benefit-cost ratio of 5.9 to 1. To achieve benefits made possible by the structural works and other management during a 15-year period, local interests will install necessary land treatment measures for erosion control and flood management, costing approximately $814,770, drainage measures expected to cost $507,617, and forest protection and management practices costing $366,280 for a total of $1,688,667. The total cost of installing the structural measures and the land treatment measures is $1,988,557.

## Projects after 1980

Projects for the years 1980-2000 and 2000-2020 are shown in Table 11-8 with their expected costs. Benefits and benefit-cost ratios have not been computed past 1980. Total installation costs are expected to be $9,025,000.

**TABLE 11-8. Costs of projects recommended for installation after 1980**

| Watershed Area No. and Name[1] | Project Area | Struc. Meas. Installation Cost[2] |
|---|---|---|
| | (acres) | (dollars) |
| 1980-2000 | | |
| 0-49 Skookum Creek | 54,301 | 290,000 |
| 0-55 Northwest Shelton | 102,601 | 260,000 |
| 0-56 South Fork Skokomish | 81,921 | 3,000,000 |
| 0-60 North Hood Canal | 32,839 | 85,000 |
| 0-62 Carr Inlet | 79,820 | 580,000 |
| 0-63 Vashon Island | 23,099 | 570,000 |
| 0-69 West Kitsap Area | 76,338 | 700,000 |
| 0-70 East Kitsap Area | 95,120 | 1,200,000 |
| 0-71 Quilcene | 77,645 | 140,000 |
| 0-72 East Jefferson | 126,166 | 540,000 |
| 0-75 Sequim Bay | 22,459 | 110,000 |
| 0-76 Johnson Creek | 15,517 | 580,000 |
| TOTAL | 787,826 | 8,055,000 |
| 2000-2020 | | |
| 0-50 Isabella | 21,902 | 100,000 |
| 0-51 Anderson Island | 6,032 | 100,000 |
| 0-52 McNeil Island | 4,217 | 370,000 |
| 0-53 Hartstene Island | 13,597 | 100,000 |
| 0-57 North Fork Skokomish | 69,841 | 100,000 |
| 0-67 Dosewallips-Duckabush | 146,133 | 100,000 |
| 0-68 East Hood Canal | 53,841 | 100,000 |
| TOTAL | 314,563 | 970,000 |

1 See Figure 11-1 for location.

2 1967 prices.

## Program

Program measures refer to on-farm and urban on-site practices which take advantage of improvements made possible by the structural works of improvement, as well as measures for watershed protection, erosion control, and water management. These measures will include seeding of improved grasses and legumes, cover crops, cropland and urban drainage development made possible by structural works of improvement, forest management practices, and irrigation development.

Table 11-9 shows a breakdown of the various practices for each of the three time periods:

**TABLE 11-9. Watershed management practices for protection and development, by time periods, West Sound Basins**

| Practice | Area (acres) | Cost[1] (thousands of dollars) | |
|---|---|---|---|
| First 15 Years | | | |
| Technical assistance & management | 1,175,018[2] | | 19,969 |
| Federal, regular | | 19,764 | |
| Federal, accelerated | | 205 | |
| Installation of practices (non-Federal) | | | 77,435 |
| State & corporate management | | 19,718 | |
| Land treatment | 804,009 | 6,108 | |
| Water management | 17,138 | 3,743 | |
| Urban drainage | 35,456 | 47,866 | |
| Total | | | 97,404 |
| 1980-2000 | | | |
| Technical assistance & management | 1,175,018[2] | | 34,779 |
| Federal, regular | | 33,142 | |
| Federal, accelerated | | 1,637 | |
| Installation of practices (non-Federal) | | | 86,923 |
| State & corporate management | | 26,291 | |
| Land treatment | 804,009 | * 8,144 | |
| Water management | 11,425 | * 2,388 | |
| Urban drainage | 37,111 | * 50,100 | |
| Total | | | 121,702 |
| 2000-2020 | | | |
| Technical assistance & management | 1,175,018[2] | | 37,291 |
| Federal, regular | | 36,336 | |
| Federal, accelerated | | 955 | |
| Installation of practices (non-Federal) | | | 83,325 |
| State & corporate management | | 26,291 | |
| Land treatment | 804,009 | * 8,144 | |
| Water management | 9,521 | * 3,257 | |
| Urban drainage | 33,802 | * 45 633 | |
| Total | | | 120,616 |

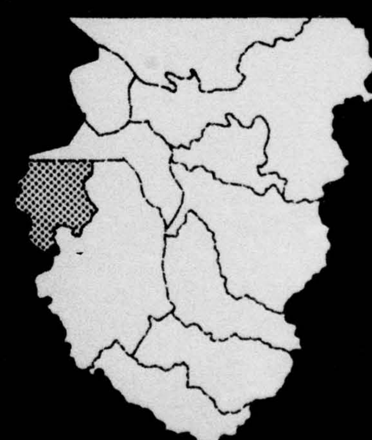
[1] Base: 1967 prices, except items asterisked which are adjusted normalized prices. (See page 2-89 et seq)

[2] Total acres in Basins involved in program measures.

## Summary of Costs

Costs for the West Sound Basins plan (projects costs plus program costs, rounded to the nearest thousand dollars) are expected to be $98,483,000 for the early action program; $129,757,000 for the years 1980-2000; and $121,586,000 for the years 2000-2020. Total cost of the plan will be $349,826,000. See page 2-89 et seq.; also page 2-95, Table 2-20, for further explanation of costs.

# Elwha-Dungeness Basins



# ELWHA-DUNGENESS BASINS

The Elwha-Dungeness Basins are located in Clallam County, with approximately one-fourth of their area in northeastern Jefferson County. Four-fifths of the area is rugged, mountainous terrain, and the balance, lying along the northern coast, is made up largely of alluvial terraces.

The headwaters of the Dungeness River originate high in the Olympic Mountains. The river flows northerly and empties into the Strait of Juan de Fuca. The drainage area is about 217 square miles. The principal tributary, Gray Wolf River, joins the Dungeness River within the confines of Olympic National Forest.

The Elwha River heads in the glaciers of the Olympic Mountains. It flows in a northerly direction and discharges into the Strait of Juan de Fuca. The Elwha River drains approximately 328 square miles. There are no important tributaries. Approximately 156 square miles drain directly into the Puget Sound.

## PRESENT STATUS

In 1963 the population was 28,300, and projections indicate that by 1980 the population will be 29,800; by 2000, 41,000; and by 2020 will reach 56,600. Population density at the present time, based on urban and rural non-farm lands, is 2.58 people per acre.

The raising of dairy and beef cattle is the principal farming enterprise, and the majority of the area is seeded pasture or hay land. Field crops, mint and peas in particular, make a significant contribution to the farming economy. Total value of farm production in the Elwha-Dungeness Basins is more than $2.5 million annually.

Forest lands are by far the biggest user of land in the Basins, comprising more than 90 percent of the total area. Forested lands total 409,000 acres, including open areas normally associated with forest, with more than 80 percent of this acreage within the Olympic National Park and Olympic National Forest.

Forest lands outside Olympic National Park support the lumbering, pulp, and paper production industry, the largest industry in the Study Area. Other important industries include hydro-electric power, recreation, commercial fishing, and farming.

The production of salmon from the Elwha and Dungeness Basins provide an important segment of the harvest of the commercial and sport fisheries of Puget Sound, Strait of Juan de Fuca and the Pacific Ocean coastal waters.

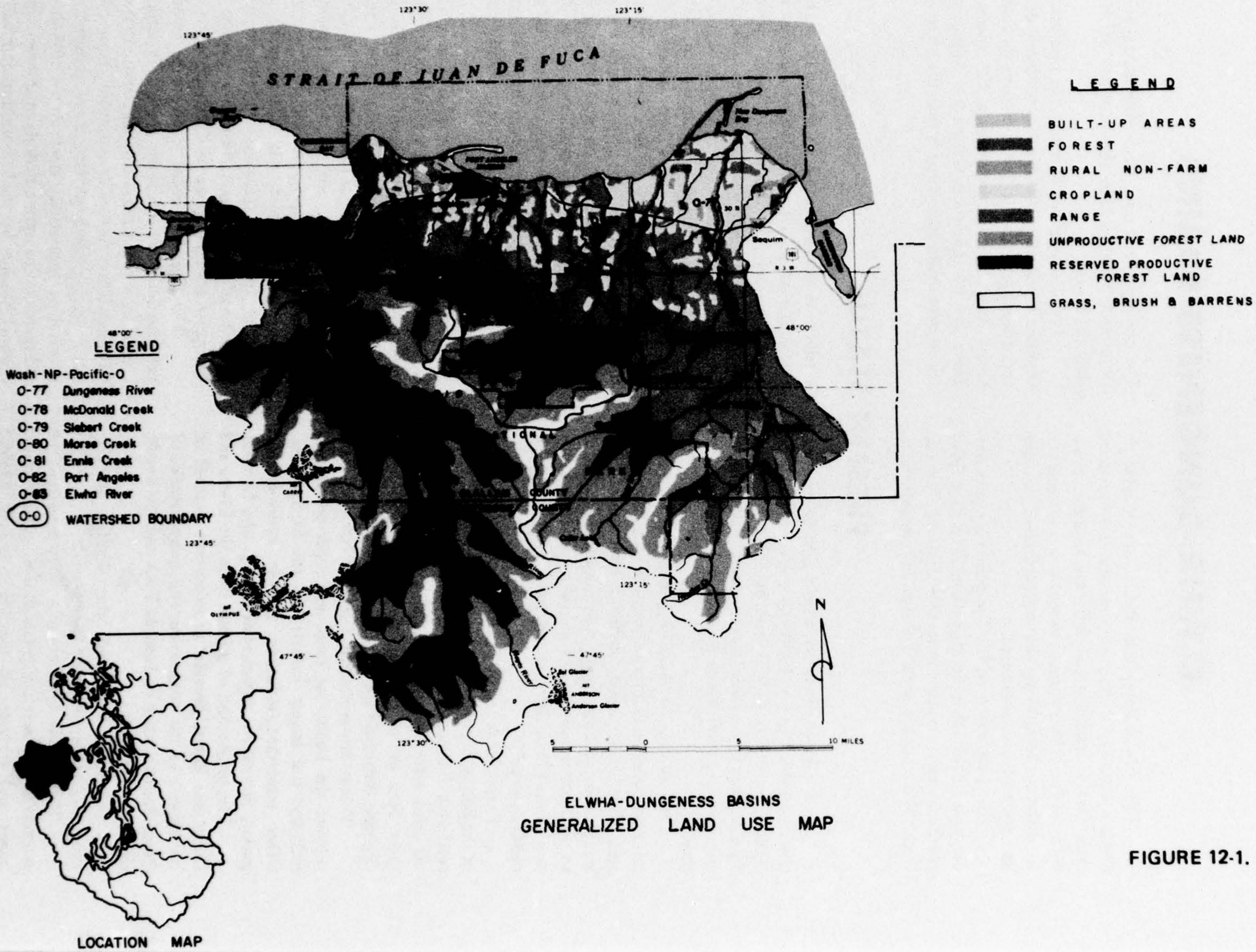
Dungeness crabs and other shellfish are economically important to the Basins.

There is a wide variety of wildlife present as the streams of the Basins originate in the rugged Olympic range and traverse all the life zones of western Washington on their route to the Strait of Juan de Fuca. The varied climate greatly influences wildlife abundance and distribution. Included among the varieties of wildlife are big game, upland game, fur-bearing animals, and various types of waterfowl.

The main recreation attractions of the Basins are the salt water, rivers and streams and the spectacular Olympic Mountains. In the lower elevations recreationists enjoy camping along the streams and salt water shoreline, fishing, hunting, gathering mushrooms, berries, and wildflowers, boating and viewing the scenery. In the high country sightseeing, hiking, mountain climbing, high lake fishing, snow skiing, and other related activities available in alpine areas are popular.

The climate of the Basins is conducive to extremes of streamflows. Late fall and winter frequently produce damaging floodflows and conversely midsummer drought produces low flow conditions which are detrimental to fish and wildlife, recreation, and to sanitation within the streams. Potential for development of streams and rivers is limited in many respects unless low flows can be augmented to some degree by structural measures and management practices. Low flow characteristics for streams in the Basins are given in Appendix III, Hydrology.

The higher altitudes receive large amounts of precipitation, but excessive erosion is largely precluded by a profuse cover of vegetation. In the lower altitudes where urban development, road construction, logging, and farming have resulted in the removal of vegetation, sheet or rill erosion of fine sediments occur during periods of intense rain. Some channel erosion by bank sloughing and bed move-




ELWHA-DUNGENESS BASINS
GENERALIZED LAND USE MAP

FIGURE 12-1.

ment also occurs, principally in areas where streams cut into glacial drift deposits near the Strait of Juan de Fuca. Sediment problems generally are local in nature and result from removal of vegetation in logging or construction operations.

## PRESENT LAND USE

The Basins include many flood and drainage problem areas which require corrective measures before their potential can be attained. The combined flood plain of the two major rivers contains about 3,000 acres of gently undultaing river bottom lands. Most of the farmland is situated on alluvial terraces above the flood plain. The upper reaches of the Basins are steep, mountainous valleys with turbutlent streams. Much of the area of the Basins lines within Olympic National Park (see Figure 12-1). The ownership distribution of the Basin's lands are shown on Figure 12-2.

The broad categories of land use are given in Table 12-1. No attempt is made here to quantify multiple use management of lands such as for game habitat, recreation, water quality, or low flow augmentation.

**TABLE 12-1. Present land use by sub-basins [1]**

| Land Use | Elwha River Basin (acres) | Dungeness River Basin (acres) | Coastal Drainages (acres) | Total (acres) |
|---|---|---|---|---|
| Cropland | 752 | 14,936 | 8,033 | 23,721 |
| Rangeland | 104 | 975 | 1,338 | 2,417 |
| Forest[2] | 206,941 | 119,500 | 83,050 | 409,491 |
| Rural non-farm | 232 | 2,266 | 2,575 | 5,073 |
| Urban built-up | 341 | 967 | 4,603 | 5,911 |
| Fresh water | 1,406 | 361 | 77 | 1,844 |
| Total | 209,776 | 139,005 | 99,676 | 448,457 |

[1] Unadjusted measurements, 1966, for Puget Sound Area Study. Tabulations by ADP. First three figures are significant figures for acreages.

[2] Includes non-forested or alpine land normally associated with forest.

## SOILS

A medium-intensity soil survey is available for most lands outside the national forest and national park boundaries. Lands within the national forests and national parks were mapped from a reconnaissance-type survey.

The mapping units are discussed in the soil survey reports for Clallam and Jefferson Counties and their locations are shown on maps. The soil survey report is available in libraries and in local offices of the United States Department of Agriculture.

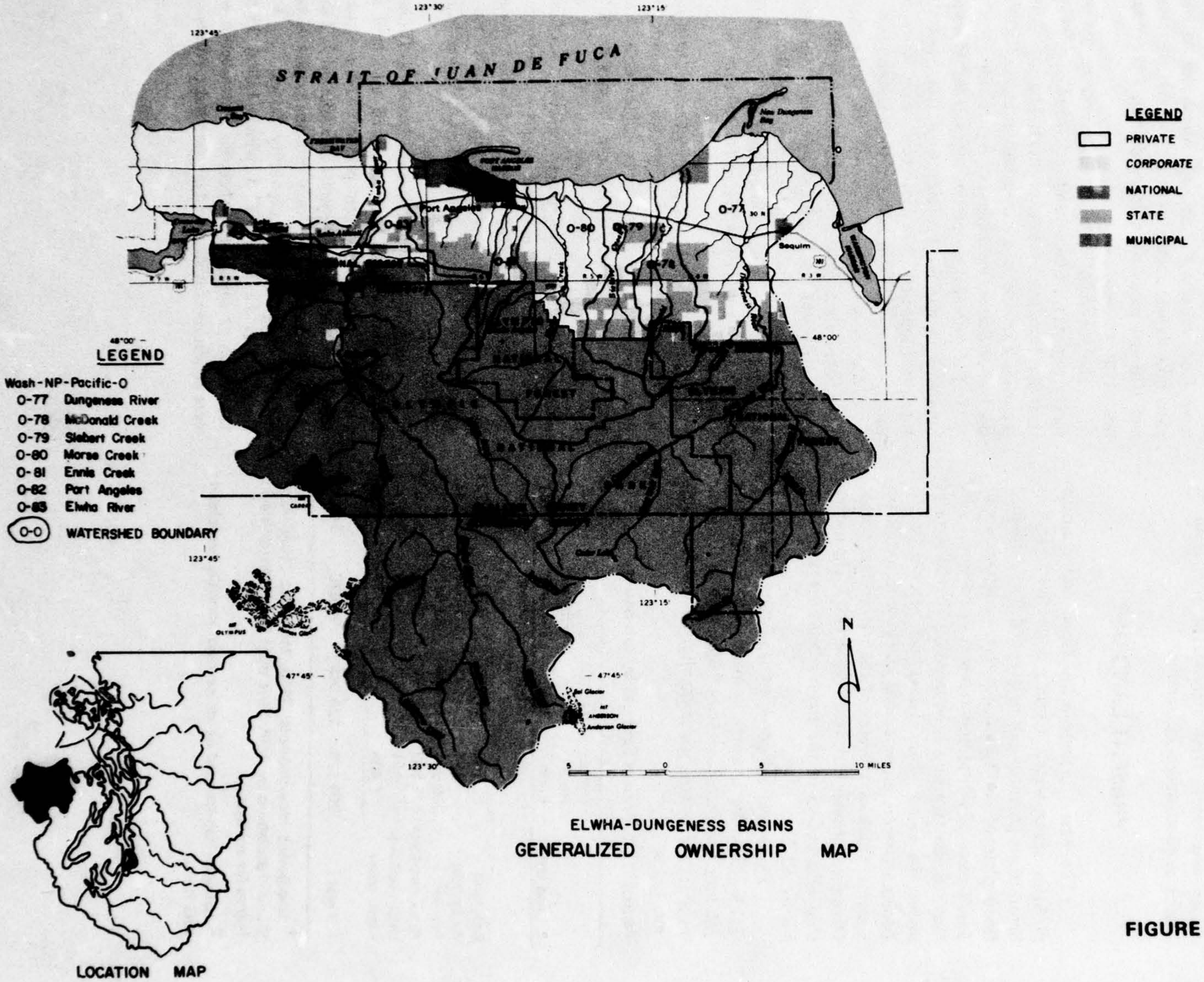
The principal properties of each soil series are tabulated in Exhibit 1, Table 6 of this Appendix. Interpretations of data for each soil series are provided in subsequent tables of the Exhibit.

The total land area of 446,600 acres in the Elwha-Dungeness Basins has a medium-intensity survey on 108,300 acres and a low-intensity survey on 338,300 acres. Of the 108,300 acres, 72,900 acres are classified in Land Capability Classes II through VI, 32,500 acres are in Class VII, and 2,900 acres in Class VIII (Figure 12-3).

Lands in Land Use Capability Classes II through VI (72,900 acres) have the greatest potential for development; i.e., changed use or improved use. Land Use Capability Classes II, III, and IV may be suited for either crops or urban uses, and Class VI has potential for urban development. Most of the Class II and Class III lands in these basins are subject to flooding and have wetness conditions which present hazards for many developed uses. Class VII is expected to be largely limited to forest use and Class VIII for recreation or aesthetic use.

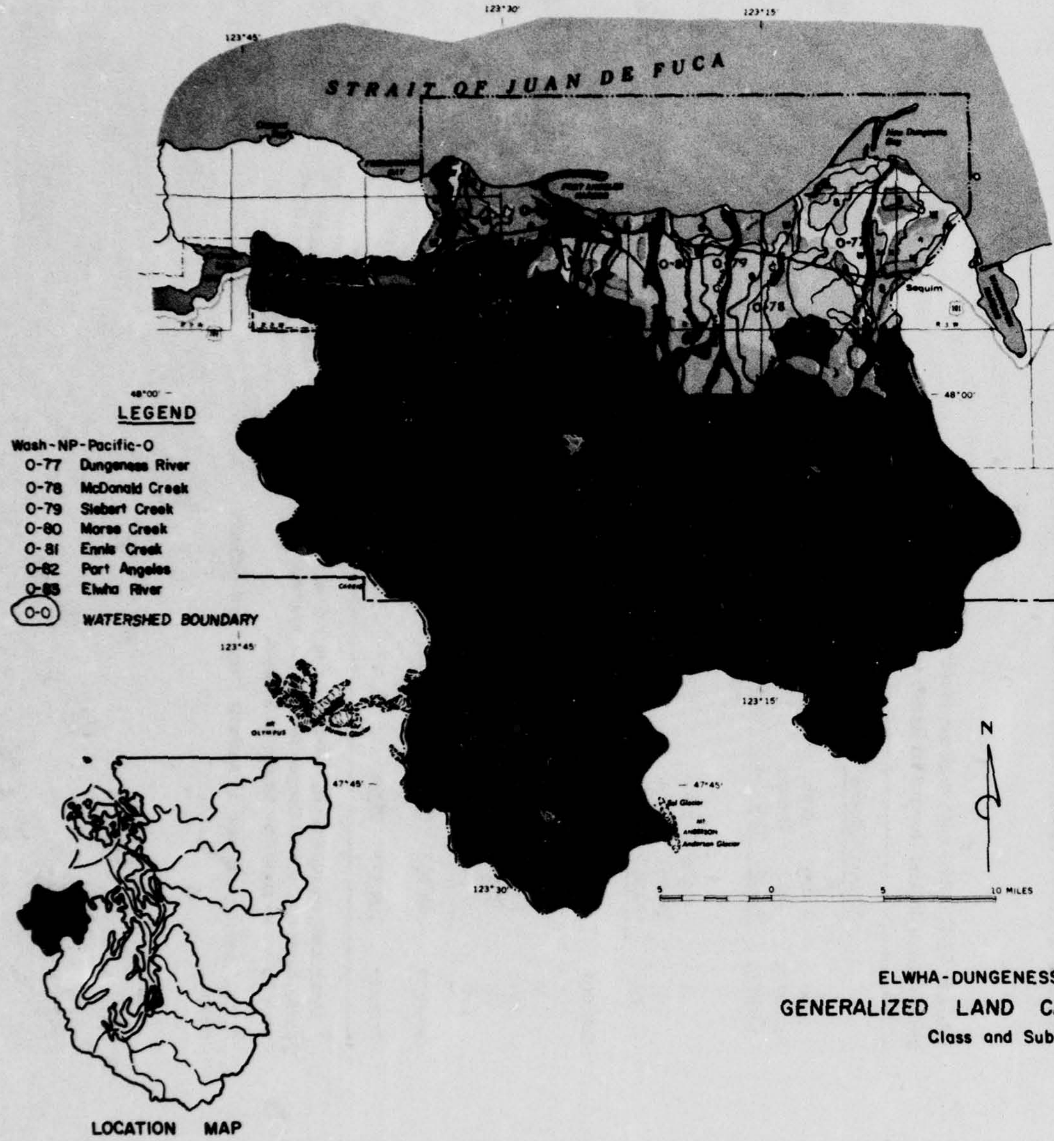
The soil types in the Area having a medium-intensity survey have been classified into land use capability classes and their primary and secondary subclasses, and capability units (see Exhibit 1, Tables 9 and 10). Lands having only reconnaissance surveys are roughly grouped into capability classes.

Tables 12-2 and 12-3 which follow give a tabulation of capability subclasses and specific wetness conditions for surveyed lands in these Basins.




ELWHA-DUNGENESS BASINS
GENERALIZED OWNERSHIP MAP

FIGURE 12- 2




L E G E N D

LAND SUITED FOR CULTIVATION AND OTHER USES

I — Soils in Class I have few limitations that restrict their use. They are well suited for cultivated crops, pasture, woodland, wildlife, and recreation.

II — Soils in Class II have some limitations that reduce the choice of plants, or require moderate conservation practices. The soils are well suited for cultivated crops, pasture, woodland, wildlife food and cover, and recreation.

III — Soils in Class III have severe limitations that reduce the choice of plants, or require special conservation practices. When used for cultivated crops, the conservation practices are usually more difficult to apply and to maintain. The soils are suited for cultivated crops, pasture, woodland, wildlife food and cover, and recreation.

IV — Soils in Class IV have very severe limitations that restrict the choice of plants, require very careful management, or both. The soils in Class IV may be used for crops, pasture, woodland, wildlife food and cover, and recreation.

LAND LIMITED IN USE
GENERALLY NOT SUITED FOR CULTIVATION

V — Soils in Class V have little or no erosion hazard but have other limitations impractical to remove that limit their use largely to pasture, range, woodland, or wildlife food and cover.

VI — Soils in Class VI have severe limitations that make them generally unsuited for cultivation and limit their use largely to pasture or range, woodland, wildlife food and cover, and recreation.

Soils in Class VII have very severe limitations that make them unsuited for cultivation and that restrict their use largely to grazing, woodland, wildlife, recreation, and water supply.

Soils and land forms in Class VIII have limitations that preclude their use for commercial plant production and restrict their use to recreation, wildlife, water supply, or esthetic purposes.

PRIMARY SUBCLASSES

e-Potential erosion or past erosion damage, sediment source.
w-Wetness, poor drainage or overflow.
s-Shallowness, stoniness or low moisture-holding capacity, etc.

ELWHA-DUNGENESS BASINS
GENERALIZED LAND CAPABILITY MAP
Class and Subclass

FIGURE 12-3.

**TABLE 12-2. Land conditions by capability classes in Elwha-Dungeness Basins (in acres)[1]**

| Class | Subclasses[2] | | | | | | | | | Class Total |
|---|---|---|---|---|---|---|---|---|---|---|
| | *e* | *w* | *s* | *ew* | *es* | *we* | *ws* | *se* | *sw* | |
| II | | | | | | | 8,424 | | | 8,424 |
| III | | | 2,903 | 23,760 | | | 4,188 | | | 30,851 |
| IV | | | 3,846 | 10,067 | | | 7,027 | | | 20,940 |
| V | | | | | | | | | | 0 |
| VI | | | 4,111 | 8,573 | | | | | | 12,684 |
| VII | | | | 655 | 31,819 | | | | | 32,474 |
| VIII | | | | 1,765 | | | 1,179 | | | 2,944 |
| TOTAL | | | 10,860 | 44,820 | 31,819 | | 20,818 | | | 103,317 |

[1] Unadjusted measurements, 1966, for Puget Sound Area Study based on National Cooperative Soil Survey maps. First three figures are significant figures for acreages. Does not include land within national forests and national parks.

[2] Letters for subclasses denote hazards or conditions that affect land use and treatment: e—erosion; w—wetness; s—soil.

**TABLE 12-3. Land with wetness condition by capability classes, Elwha-Dungeness Basins (in acres) [1]**

| | All land in basins[2] | | Cropland in basins | |
|---|---|---|---|---|
| Land *Capability* Classes | Total All Land | With *Wetness* Condition | Total Cropland (est.) | Cropland With Wetness Condition (est.) |
| II | 8,424 | 8,424 | 8,003 | 8,003 |
| III | 30,851 | 27,948 | 3,858 | 3,495 |
| IV | 20,940 | 17,094 | 11,860 | 8,960 |
| Subtotal | 60,215 | 53,466 | 23,721 | 20,458 |
| V | 0 | 0 | 0 | 0 |
| VI | 12,684 | 8,573 | 0 | 0 |
| VII | 32,474 | 655 | 0 | 0 |
| VIII | 2,944 | 2,944 | 0 | 0 |
| Subtotal | 48,102 | 12,172 | 0 | 0 |
| TOTAL | 108,317 | 65,638 | 23,721 | 20,458 |

[1] Unadjusted measurements, 1966, for Puget Sound Area Study, based on National Cooperative Soil Survey maps. First three figures are significant figures for acreages.

[2] Does not include land in national forests and national parks.

# PRESENT AND FUTURE NEEDS

## EVALUATION OF PRESENT SITUATION

The primary use of land in the Elwha-Dungeness Basins is for forest, with a large portion of these forested lands being contained within the Olympic Naitonal Forest and Olympic National Park. Three broad categories of needs–protection from floodwater damage, measures for watershed protection and rehabilitation, and measures for water management–are present in varying degrees of intensity according to land use. About 23,721 acres are in forest (including some non-forested areas); 2,417 acres are in rangeland; and 10,984 acres are in more intensive land uses.

## ESTIMATED FUTURE NEEDS

Determination of needs is made on the basis of multiple-use management and the categories of floodwater damage reduction, watershed protection and rehabiliation measures, and water management contain the practices needed for development under the concept. Development needed in forestry and farming is to keep pace with other needs as the population increases and reach the level required by 2020.

Future needs are given in acres of land to be treated. Intensity of degree of practice application will increase with use. Management practices for enhancement of multipe-use objectives may require several practices on the same acre of land. A partial listing of practices used is given in Tables 2-18 and 2-19 in the Puget Sound Area section of this Appendix under Means to Satisfy Needs.

The projected rise of population in these Basins will not be enough to require structural measures before 1980. Nonstructural measures such as flood plain management and land treatment measures will be utilized in this time frame. A summation of projects needed after 1980 is found in the Means to Satisfy Needs section of these Basins.

Little land use change is expected in these Basins but some development will occur. The estimated number of acres, according to land use, that will require protective and development measures by the years 1980, 2000, and 2020 are tabulated in Table 12-4. The same land area may require more than one of these practices.

**TABLE 12-4. Future needs for watershed management[1]**

| Year | Floodwater Damage[2] Reduction[3] (acres) | Watershed Protection & Rehab.[3] (acres) | Drainage Improvement[3] (acres) | Irrigation Development[2][4] (acres) |
|---|---|---|---|---|
| Cropland | | | | |
| 1980 | 13,747 | 26,278[5] | 9,644 | 17,000 |
| 2000 | 13,747 | 26,348[5] | 16,073 | 18,000 |
| 2020 | 13,747 | 26,417[5] | 21,430[6] | 22,000 |
| Intensive Land Use | | | | |
| 1980 | 1,900 | 10,984 | 10,984 | 0 |
| 2000 | 1,900 | 10,984 | 10,984 | 0 |
| 2020 | 1,900 | 10,984 | 10,984 | 0 |
| Forested Land[7] | | | | |
| 1980 | 0 | 409,351 | 0 | 0 |
| 2000 | 0 | 409,281 | 0 | 0 |
| 2020 | 0 | 409,212 | 0 | 4,100[8] |

1 Acreages derived by map measurements and ADP tabulation for the PS&AW study. Other potential not tabulated. Unrounded figures do not denote accuracy beyond the first three significant figures.

2 Includes overbank flooding of main streams.

3 Needed for full agricultural development (see Appendix V, Water-Related Land Resources, chapter 2, Agriculture).

4 According to Appendix VII, Irrigation, there were 15,900 acres (using 43,566 acres feet of water) irrigated in 1966. Irrigation Appendix projections show 21,900 acres irrigated by 1980; 21,900 acres by 2000; and 21,900 acres by 2020.

5 Includes 2,417 acres of rangeland.

6 Does not agree with Table 12-3 due to land use changes during time lapse.

7 Includes non-forested land commonly associated with forested areas.

8 Potential irrigation of forests (see Appendix V, chapter 3, Forestry).

Table 12-5 shows drainage groups in the watersheds of the Elwha-Dungeness Basins, with the acreage of land falling into each group. From this and other data the drainage needs for expected land uses in the Basins are derived.

**TABLE 12-5. Drainage groups in Elwha-Dungeness Basins[1] (in acres)[2]**

| LINE | Watershed Area No.[3] | River Basins and Watersheds | 01 | 02 | 03 | 04 | 05 | 06 | 07 | 08 | 09 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Dungeness River | | | | | | | | | | | | | | | | | |
| 1 | 0-77 | Dungeness River | 8,069 | 0 | 485 | 0 | 0 | 1,369 | 4,190 | 0 | 1,151 | 0 | 7,127 | 0 | 0 | 54 | 0 | 1,651 | 24,096 |
| 2 | | Total | 8,069 | 0 | 485 | 0 | 0 | 1,369 | 4,190 | 0 | 1,151 | 0 | 7,127 | 0 | 0 | 54 | 0 | 1,651 | 24,096 |
| | | Puget Sound Drainages | | | | | | | | | | | | | | | | | |
| 3 | 0-78 | McDonald Creek | 180 | 0 | 15 | 0 | 0 | 1,250 | 1,916 | 0 | 197 | 0 | 4,107 | 0 | 0 | 20 | 0 | 58 | 7,743 |
| 4 | 0-79 | Siebert Creek | 2 | 0 | 207 | 0 | 0 | 1,070 | 2,789 | 0 | 433 | 0 | 4,016 | 0 | 0 | 10 | 0 | 0 | 8,527 |
| 5 | 0-80 | Morse Creek | 209 | 0 | 93 | 0 | 0 | 167 | 2,673 | 0 | 525 | 0 | 6,744 | 0 | 0 | 0 | 0 | 71 | 10,482 |
| 6 | 0-81 | Ennis Creek | 84 | 0 | 9 | 0 | 0 | 37 | 585 | 0 | 68 | 0 | 934 | 0 | 0 | 0 | 0 | 0 | 1,717 |
| 7 | 0-82 | Port Angeles | 498 | 0 | 70 | 0 | 0 | 931 | 6,611 | 0 | 376 | 0 | 1,487 | 0 | 0 | 0 | 0 | 0 | 9,973 |
| 8 | | Total | 973 | 0 | 394 | 0 | 0 | 3,455 | 14,574 | 0 | 1,599 | 0 | 17,288 | 0 | 0 | 30 | 0 | 129 | 38,442 |
| | | Elwha River | | | | | | | | | | | | | | | | | |
| 9 | 0-83 | Elwha River | 337 | 0 | 251 | 0 | 0 | 404 | 1,314 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 794 | 3,100 |
| 10 | | Total | 337 | 0 | 251 | 0 | 0 | 404 | 1,314 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 794 | 3,100 |
| 11 | | Grand Total | 9,379 | 0 | 1,130 | 0 | 0 | 5,228 | 20,078 | 0 | 2,750 | 0 | 24,415 | 0 | 0 | 84 | 0 | 2,574 | 65,638 |

[1] Descriptions of drainage groups are found in the Means to Satisfy Needs section of the Area report.

[2] Unadjusted measurements, 1966, for Puget Sound Area Study. Tabulations by ADP. Read three signficant figures.

[3] See Figure 12-1 for location.

# MEANS TO SATISFY NEEDS

Projection indicate that by the year 2020 population in these Basins will be 56,600. Means set forth to achieve the levels necessary to meet the needs of this expected population consist of programs and projects for protection and development of the land and water resources of these Basins. The wise use and development of these resources can supply the spatial needs and aesthetic wants of an expanding population. The needs as developed in other appendices have been considered herein as being related to the land and water resources of the Elwha-Dungeness Basins.

The objectives of the plan for watershed management are to develop the Basins' resources to achieve their potential production of food and fiber as economically justified, to preserve and enhance fish, wildlife, and recreation values in accord with the Fish and Wildlife, and Recreation Appendices, to provide for development of urban areas not subject to floodwater hazard, and to provide spatial needs in keeping with aesthetic qualities of the Area. These objectives will be carried out by various agencies of the Federal and State governments working in close cooperation with each other and with private sources.

**TABLE 12-6. Estimated future land use**

| Year | Crop-land (acres) | Range-land (acres) | Forest[1] (acres) | Urban Built-up[2] (acres) | Fresh water (acres) | Total (acres) |
|---|---|---|---|---|---|---|
| 1980 | 23,861 | 2,417 | 409,351 | 10,984 | 1,844 | 448,457 |
| 2000 | 23,931 | 2,417 | 409,281 | 10,984 | 1,844 | 448,457 |
| 2020 | 24,000 | 2,417 | 409,212 | 10,984 | 1,844 | 448,457 |

[1] Includes non-forested land normally associated with forest.

[2] Rural non-farm is assumed to be all urban by 1980. Built-up based on average urban density of six persons per acre.

## Land Use

Table 12-1 in Present Status indicates by sub-basins the present land use. Table 12-6 summarizes by time periods the estimated future use of the land.

## Flooding

Floodwater damage must be prevented to the extent the hazard remaining does not materially exceed other risks before development is practical. Loss is limited to tolerable levels by restricting intensive use of land in hazardous areas, followed by feasible damage prevention and enhancement measures for suitable land use. Programs and projects are planned to stabilize land and related water and thus benefit most functional uses of water. Special objectives for improvement may be selected for project purposes.

# PLAN OF DEVELOPMENT

This plan to provide for the satisfaction of the needs, as brought out in the Needs discussion, will utilize the program and project approach, as explained in the Puget Sound Area section. The plan will guide the development of the resources of the Elwha-Dungeness Basins to provide for spatial and production requirements for the expected population of its service ara to the year 2020. Flood prevention and low flow augmentation projects would be beneficial for fish, wildlife, and recreation areas on the Dungeness River and its major tributary, the Gray Wolf River, and on the lower Elwha River. No projects are planned in these Basins before 1980.

## Projects after 1980

Several projects will be initiated in the 1980-2000 and 2000-2020 time periods to remedy existing floodwater and drainage conditions and to dvelop lands toward their potential for continued use. Benefits and benefit-cost ratios have not been computed for projects beyond 1980. Total installation costs are expected to be $3,262,000. Table 12-7 gives brief summaries of projects included in this plan:

**TABLE 12-7. Costs of projects recommended for installation after 1980**

| Watershed Area No. and Name[1] | Project Area (acres) | Struc. Meas. Installation Cost[2] (dollars) |
|---|---|---|
| 1980-2000 | | |
| 0-77 Dungeness River | 138,644 | 1,850,000 |
| 0-78 McDonald Creek | 15,953 | 270,000 |
| 0-79 Siebert Creek | 15,077 | 300,000 |
| 0-80 Morse Creek | 46,253 | 336,000 |
| 0-82 Port Angeles | 16,240 | 206,000 |
| TOTAL | 232,167 | 2,962,000 |
| 2000-2020 | | |
| 0-81 Ennis Creek | 6,076 | 100,000 |
| 0-83 Elwha River | 208,370 | 200,000 |
| TOTAL | 214,446 | 300,000 |

[1] See Figure 12-1 for location.

[2] 1967 prices.

## Programs

Program measures refer to on-farm and urban on-site practices which take advantage of improvements made possible by the structural works of improvement, as well as measures for watershed protection, erosion control, and water management. These measures will include seeding of improved grasses and legumes, cover crops, cropland and urban drainage development made possible by structural works of improvement, forest management practices, and irrigation development.

Table 12-8 shows a breakdown of the various practices for each of the three time periods.

## Summary of Costs

Costs for the Elwha-Dungeness Basins plan (projects costs plus program costs rounded to the nearest thousand dollars) are expected to be $17,852,000 for the early action program; $26,191,000 for the years 1980-2000; and 24,737,000 for the years 2000 through 2020. Total cost of the plan will be $68,780,000. See page 2-89 et seq., also page 2-95, Table 2-20, for further explanation of costs.

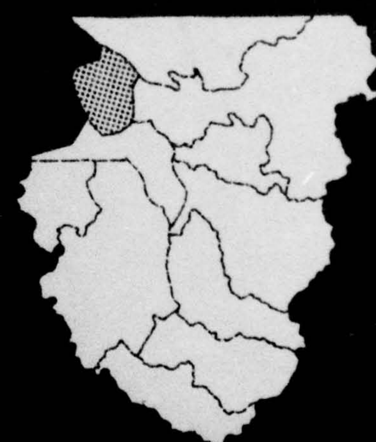
**TABLE 12-8. Watershed management practices for protection and development, by time periods, Elwha-Dungenss Basins**

| Practice | Area (acres) | Cost[1] (thousands of dollars) | |
|---|---|---|---|
| **First 15 Years** | | | |
| Technical assistance & management | 435,629[2] | | 7,037 |
| Federal, regular | | 7,037 | |
| Federal, accelerated | | 0 | |
| Installation of Practice (non-Federal) | | | 10,815 |
| State & corporate management | | 2,205 | |
| Land treatment | 95,072 | 1,907 | |
| Water management | 9,644 | 1,761 | |
| Urban drainage | 3,661 | 4,942 | |
| Total | | | 17,852 |
| **1980-2000** | | | |
| Technical assistance & management | 435,629[2] | | 11,719 |
| Federal, regular | | 11,487 | |
| Federal, accelerated | | 232 | |
| Installation of practices (non-Federal) | | | 11,510 |
| State & corporate management | | 2,940 | |
| Land treatment | 95,072 | * 2,542 | |
| Water management | 6,429 | * 1,227 | |
| Urban drainage | 3,556 | * 4,801 | |
| Total | | | 23,229 |
| **2000-2020** | | | |
| Technical assistance & management | 435,629[2] | | 12,214 |
| Federal, regular | | 12,121 | |
| Federal, accelerated | | 93 | |
| Installation of practice (non-Federal) | | | 12,223 |
| State & corporate management | | 2,940 | |
| Land treatment | 95,072 | * 2,542 | |
| Water management | 5,357 | * 1,656 | |
| Urban drainage | 3,767 | * 5,085 | |
| Total | | | 24,437 |

[1] Base: 1967 prices, except items asterisked which are adjusted normalized prices. (See page 2-89 et seq.)

[2] Total acres in Basins involved in program measures.

# San Juan Islands



# SAN JUAN ISLANDS

The San Juan Islands study area is comprised of all of San Juan County. The San Juan Islands lie in Puget Sound along the coast in the northwestern part of the State of Washington.

Of the 473 islands visible at low tide, only six are of major importance. They are: Orcas Island, with an area of 58 square miles; San Juan, 55 square miles; Lopez, 29 square miles; Shaw, 8 square miles; Blakely, 7 square miles; Waldron, 5 square miles; and Decatur, 3 square miles. The rest of the islands including Stuart, Henry, Spieden and Sucia, grouped together contain about 11 square miles.

# PRESENT STATUS

In 1963 the population was 2,600, and the projections indicate that by 1980 population will be 2,800; by 2000, 3,700; and by the year 2020 will reach 5,100. Present population density, based on urban and rural non-farm lands, is .22 people per acre.

Although both forestry and farming have declined in importance, they are still the biggest users of land. Many farming enterprises that were formerly of primary importance have virtually disappeared. Most notable are dairying, poultry, processing peas, tree fruits, berries, and seed potatoes. Beef and sheep have gradually replaced dairy cattle in numbers as the market for cream has declined. Total value of farm production of the San Juan Islands is over $500,000 annually.

The main reasons for decline of the forest industry are lower prices offered on the mainland, fewer markets, and a general depletion of local timber resources. Forest lands comprise about 72,000 acres, including open areas normally associated with forest.

Industrialization of the Islands has been limited. Certain industries that were active in past years are no longer producing. Logging and timber operations, while still operating, have declined noticeably in recent years. Farming activities have also been declining, giving way to recreation and urban development. The economy of the Islands is now balanced around agriculture, fishing and recreation.

The Islands support virtually no anadromous fish population. However the marine waters and channels throughout the archipelago, as well as the Straits of Juan de Fuca, adjacent to these Islands are well defined migration routes of salmon runs. The major portion of the Puget Sound commercial harvest occurs within these waters. Sport fishing for salmon and other marine species provides exceptional recreational opportunities. Friday Harbor is an important port for the commercial fishing fleet and derives most of its economy from the fisheries resource. The San Juan Islands economy is highly dependent on its attractive recreational facilities.

The migratory waterfowl which inhabit the Islands are primarily transitory, using the numerous islands and protected salt water areas only seasonally. Freshwater areas are limited, thereby limiting the types of fur-bearing animals found here. Ring-necked pheasant and two species of rabbits are the principal upland game found in the Islands. The only big game species inhabiting the Islands is the black-tailed deer.

The San Juan Islands are among the most scenic and outstanding recreation atttractions in the Pacific Northwest. With the greater emphasis on safeguarding and increasing the number of public-use areas and quality-type commercial facilities, the Islands have the potential of becoming an outstanding year around vacation land and water sportsman's paradise. Significant assets include opportunities for abundant water-oriented recreation activities and an excellent mild and dry climate.

Because of their location in the rain shadow of the Olympic Mountains and Vancouver Islands uplands, the San Juand Islands receive less precipitation than the mainland to the east.

Sediment problems are minor and occur in localized areas of construction or farming. In some places soils are eroded by rapid runoff from higher rocky areas.

## PRESENT LAND USE

The San Juan Islands study area provides the smallest system in the Puget Sound Area. It drains a total area of only 176 square miles. Drainage is

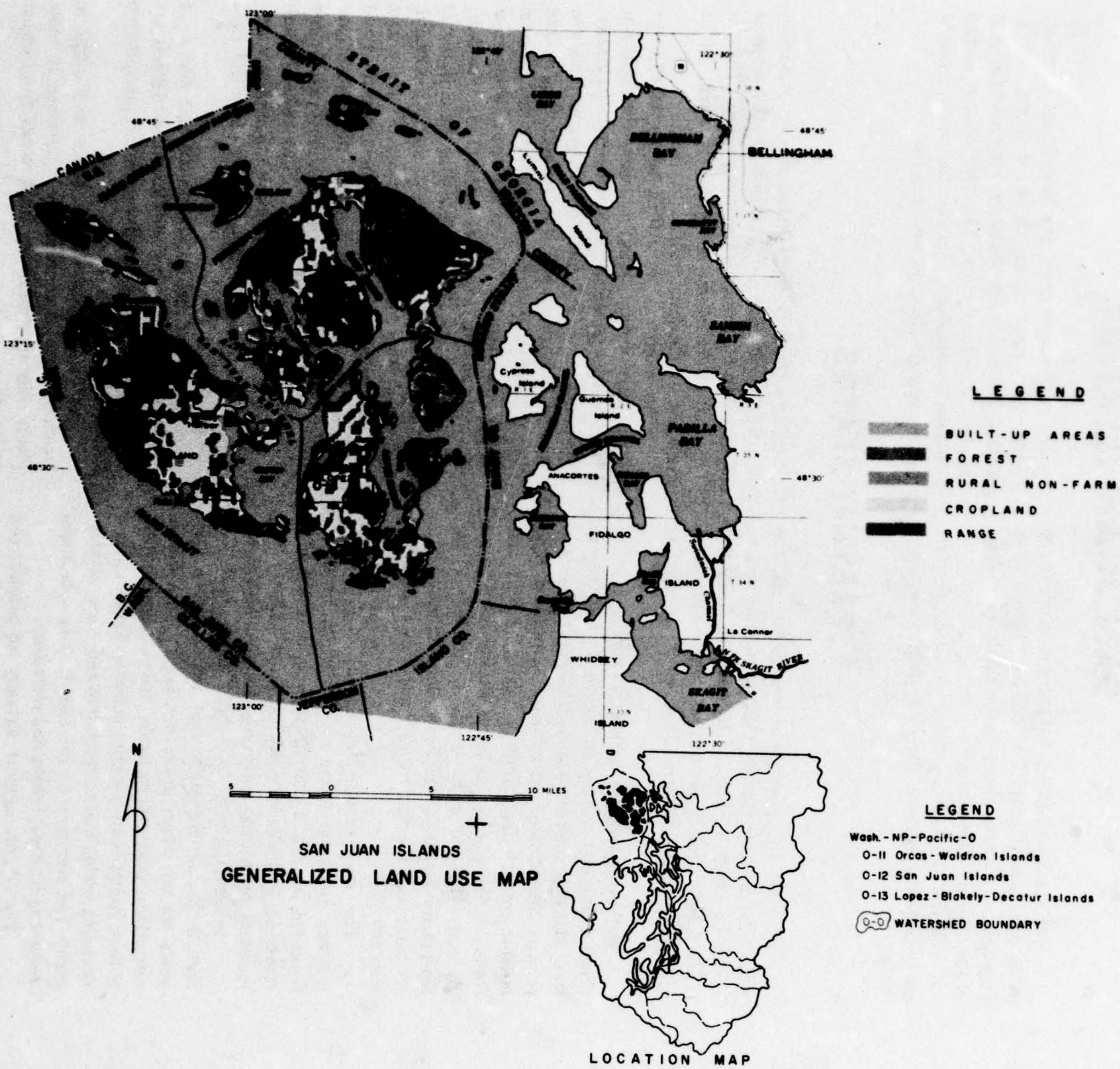

SAN JUAN ISLANDS
GENERALIZED LAND USE MAP
LEGEND
BUILT-UP AREAS
FOREST
RURAL NON-FARM
CROPLAND
RANGE
BELLINGHAM
STRAIT OF GEORGIA
CANADA
Cypress Island
Guemes Island
ANACORTES
FIDALGO
ISLAND
WHIDBEY
ISLAND
La Conner
SKAGIT RIVER
SKAGIT BAY
JEFFERSON CO.
ISLAND CO.
123°00'
123°15'
122°45'
122°30'
48°45'
48°30'
10 MILES
N
LEGEND
Wash. - NP - Pacific - O
O-11 Orcas - Waldron Islands
O-12 San Juan Islands
O-13 Lopez - Blakely - Decatur Islands
WATERSHED BOUNDARY
LOCATION MAP

FIGURE 13-1.

accomplished through minor streams that flow directly into the bay. Although the system has only minor streams, it does have a great deal of flooding by ponding and drainage problem areas which require water control measures before potential may be attained. The landscape of the Islands is marked by abrupt differences in elevation. The glacial plains are characterized by low relief with gently rolling hills and basin-like areas. There are 15 mountain peaks on the Islands that exceed 1,000 feet; the highest being Mount Constitution on Orcas Island at 2,409 feet (Figure 13-1)The ownership distribution of the Islands' lands are shown on Figure 13-2.

The broad categories of land use are given in Table 13-1 which follows. No attempt is made here to quantify multiple-use management of lands such as for game habitat, recreation, water quality, or low flow augmentation.

**TABLE 13-1. Present land use by basin**[1]

| Land Use | San Juan Islands *(acres)* | Total *(acres)* |
|---|---|---|
| Cropland | 18,594 | 18,594 |
| Rangeland | 9,129 | 9,129 |
| Forest[2] | 71,958 | 71,958 |
| Rural non-farm | 9,118 | 9,118 |
| Urban built-up | 2,774 | 2,774 |
| Fresh water | 955 | 955 |
| Total | 112,528 | 112,528 |

[1] Unadjusted measurements, 1966, for Puget Sound Area Study. Tabulations by ADP. First three figures are significant figures in acreages.

[2] Includes non-forested areas normally associated with forest.

## SOILS

A medium-intensity soil survey is available for all lands within the islands.

The mapping units are discussed in the soil survey report for San Juan County and their locations are shown on maps. The soil survey report is available in libraries and in local offices of the United States Department of Agriculture.

The principal properties of each soil series are tabulated in Exhibit 1, Table 6 of this Appendix. Interpretations of dat for each soil series are provided in subsequent tables of the Exhibit.

The total land area of 111,600 acres in the San Juan Islands has been surveyed by a medium-intensity soil survey. Of the 111,600 acres, 88,100 acres are classified in Land Capability Classes II through VI, 22,200 acres are in Class VII, and 1,300 acres in Class VIII (Figure 13-3).

Lands in Land Use Capability Classes II through VI (88,100 acres) have the greatest potential for development; i.e., changed use or improved use. Land Use Capability Classes II, III, and IV may be suited for either crops or urban uses, and Class VI has potential for urban development. Most of the Class II *and Class III lands in these Islands are subject to* flooding and have wetness conditions which present hazards for many developed uses. Class VI is expected to be largely limited to forest use and Class VIII for recreation or aesthetic use.

The soil types in the Area having a medium-intensity survey have been classified into land use capability classes and their primary and secondary subclasses, and capability units are roughly grouped into capability classes (see Exhibit 1, Tables 9 and 10).

Tables 13-2 and 13-3 which follow give a tabulation of capability subclasses and specific wetness conditions for surveyed lands in these Islands.

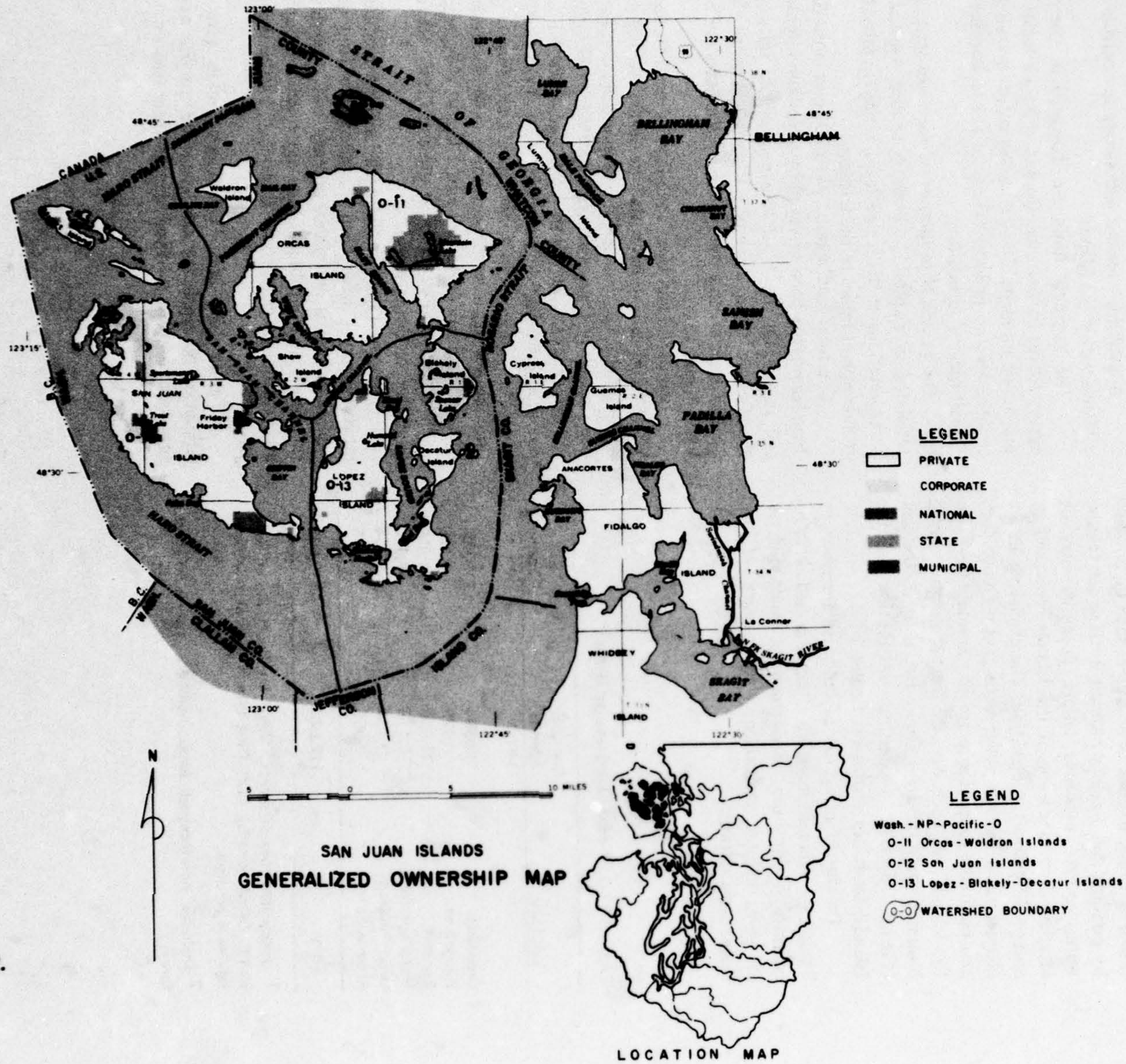

CANADA
U.S.
STRAIT OF GEORGIA
WHATCOM COUNTY
BELLINGHAM
BELLINGHAM BAY
SAMISH BAY
PADILLA BAY
SKAGIT BAY
SKAGIT RIVER
La Conner
Waldron Island
ORCAS ISLAND
O-11
Shaw Island
SAN JUAN ISLAND
Friday Harbor
LOPEZ ISLAND
O-13
Blakely Island
Decatur Island
Cypress Island
Guemes Island
ANACORTES
FIDALGO ISLAND
WHIDBEY ISLAND
HARO STRAIT
SAN JUAN CO.
CLALLAM CO.
JEFFERSON CO.
ISLAND CO.
123°15'
123°00'
122°45'
122°30'
48°45'
48°30'
LEGEND
PRIVATE
CORPORATE
NATIONAL
STATE
MUNICIPAL
N
5 0 5 10 MILES
SAN JUAN ISLANDS
GENERALIZED OWNERSHIP MAP
LEGEND
Wash. - NP - Pacific - O
O-11 Orcas - Waldron Islands
O-12 San Juan Islands
O-13 Lopez - Blakely - Decatur Islands
O-O WATERSHED BOUNDARY
LOCATION MAP

FIGURE 13-2.

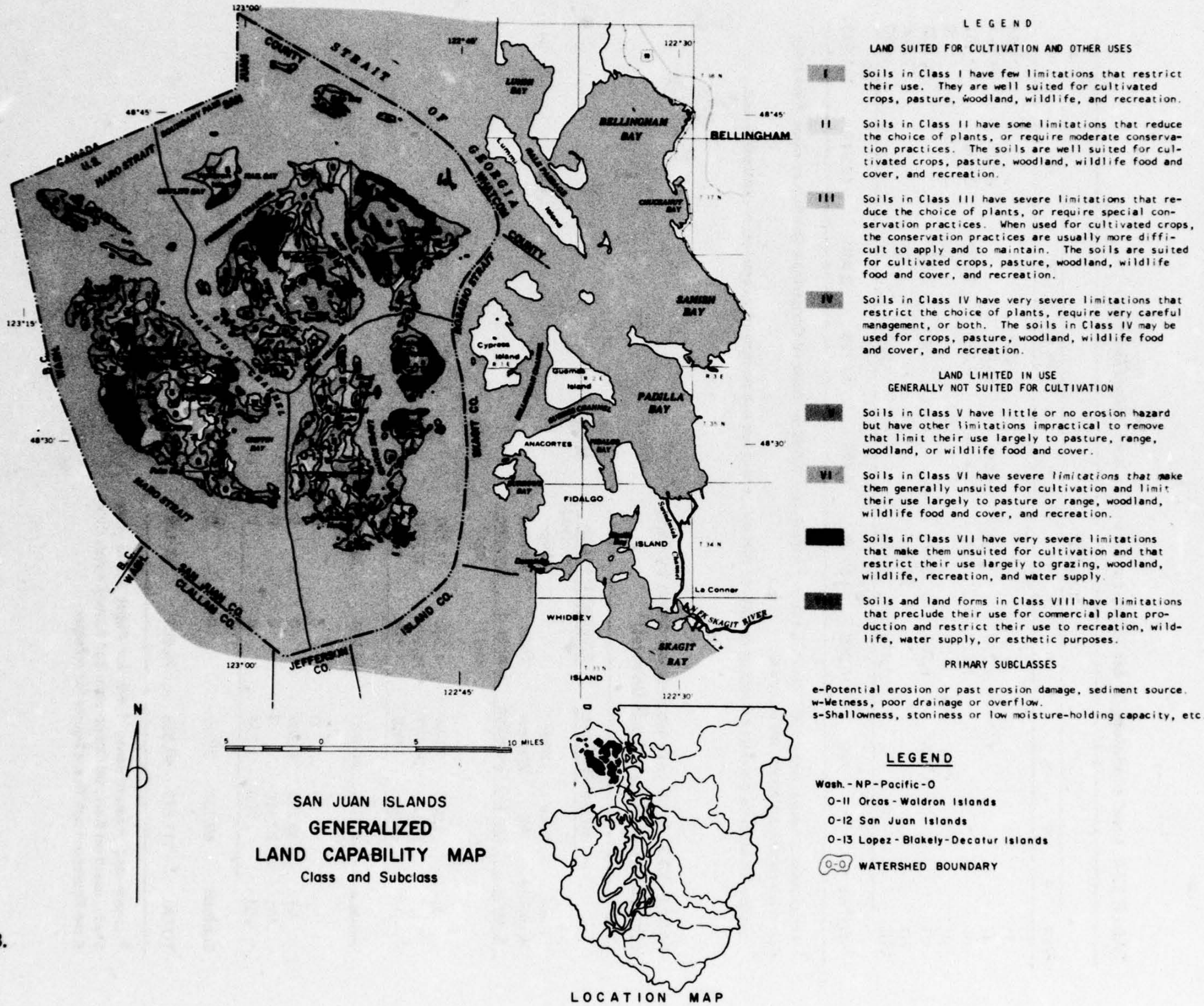

LEGEND
LAND SUITED FOR CULTIVATION AND OTHER USES
I Soils in Class I have few limitations that restrict their use. They are well suited for cultivated crops, pasture, woodland, wildlife, and recreation.
II Soils in Class II have some limitations that reduce the choice of plants, or require moderate conservation practices. The soils are well suited for cultivated crops, pasture, woodland, wildlife food and cover, and recreation.
III Soils in Class III have severe limitations that reduce the choice of plants, or require special conservation practices. When used for cultivated crops, the conservation practices are usually more difficult to apply and to maintain. The soils are suited for cultivated crops, pasture, woodland, wildlife food and cover, and recreation.
IV Soils in Class IV have very severe limitations that restrict the choice of plants, require very careful management, or both. The soils in Class IV may be used for crops, pasture, woodland, wildlife food and cover, and recreation.
LAND LIMITED IN USE
GENERALLY NOT SUITED FOR CULTIVATION
Soils in Class V have little or no erosion hazard but have other limitations impractical to remove that limit their use largely to pasture, range, woodland, or wildlife food and cover.
VI Soils in Class VI have severe limitations that make them generally unsuited for cultivation and limit their use largely to pasture or range, woodland, wildlife food and cover, and recreation.
Soils in Class VII have very severe limitations that make them unsuited for cultivation and that restrict their use largely to grazing, woodland, wildlife, recreation, and water supply.
Soils and land forms in Class VIII have limitations that preclude their use for commercial plant production and restrict their use to recreation, wildlife, water supply, or esthetic purposes.
PRIMARY SUBCLASSES
e-Potential erosion or past erosion damage, sediment source.
w-Wetness, poor drainage or overflow.
s-Shallowness, stoniness or low moisture-holding capacity, etc.
LEGEND
Wash.-NP-Pacific-O
O-11 Orcas-Waldron Islands
O-12 San Juan Islands
O-13 Lopez-Blakely-Decatur Islands
O-O WATERSHED BOUNDARY
SAN JUAN ISLANDS
GENERALIZED
LAND CAPABILITY MAP
Class and Subclass
LOCATION MAP
10 MILES
N
STRAIT OF GEORGIA
WHATCOM COUNTY
SKAGIT CO.
ISLAND CO.
JEFFERSON CO.
SAN JUAN CO.
CLALLAM CO.
HARO STRAIT
CANADA
U.S.
B.C.
WASH.
BELLINGHAM
BELLINGHAM BAY
SAMISH BAY
PADILLA BAY
SKAGIT BAY
ANACORTES
FIDALGO
ISLAND
WHIDBEY
ISLAND
La Conner
Cypress Island
Guemes Island
Swinomish Channel
123°00'
123°15'
123°00'
122°45'
122°30'
48°45'
48°30'

FIGURE 13-3.

**TABLE 13-2. Land conditions by capability classes in San Juan Islands (in acres)[1]**

| Class | Subclasses[2] e | w | s | ew | es | we | ws | se | sw | Class Total |
|---|---|---|---|---|---|---|---|---|---|---|
| II | | | | | | | 1,284 | | | 1,284 |
| III | | | | 1,776 | | 4,595 | 10,819 | | 8,477 | 25,667 |
| IV | | | | 7,674 | 20 | | 2,325 | 1,002 | 3,870 | 14,891 |
| V | | | | | | | | | | 0 |
| VI | | | 4,749 | 6,206 | 33,124 | | 79 | 2,067 | | 46,225 |
| VII | | | | | 22,156 | | | | | 22,156 |
| VIII | | | | 1,013 | 116 | | 221 | | | 1,350 |
| TOTAL | | | 4,749 | 16,669 | 55,416 | 4,595 | 14,728 | 3,069 | 12,347 | 111,573 |

[1] Unadjusted measurements, 1966, for Puget Sound Area Study, based on National Cooperative Soil Survey maps. First three figures are significant figures for acreages.

[2] Letters for subclasses denote hazards or conditions that affect land use and treatment: e—erosion; w—wetness; s—soil.

**TABLE 13-3. Land with wetness condition by capability classes, San Juan Islands (in acres)[1]**

| Land Capability Classes | All land in islands: Total All Land | All land in islands: With Wetness Condition | Cropland in islands: Total Cropland (est.) | Cropland in islands: Cropland With Wetness Condition (est.) |
|---|---|---|---|---|
| II | 1,284 | 1,284 | 1,220 | 1,220 |
| III | 25,667 | 25,667 | 16,198 | 15,875 |
| IV | 14,891 | 13,869 | 1,176 | 1,095 |
| Subtotal | 41,842 | 40,820 | 18,594 | 18,190 |
| V | 0 | 0 | 0 | 0 |
| VI | 46,225 | 6,285 | 0 | 0 |
| VII | 22,156 | 0 | 0 | 0 |
| VIII | 1,350 | 1,234 | 0 | 0 |
| Subtotal | 69,731 | 7,519 | 0 | 0 |
| TOTAL | 111,573 | 48,339 | 18,594 | 18,190 |

[1] Unadjusted measurements, 1966, for Puget sound Area Study, based on National Cooperative Soil Survey maps. First three figures are significant figures for acreages.

# PRESENT AND FUTURE NEEDS

## EVALUATION OF PRESENT SITUATION

In the San Juan Islands three broad categories of needs—protection from floodwater damage, measures for watershed protection and rehabilitation, and measures for water management—are present in varying degrees of intensity according to land use. About 18,594 acres are now used for cropland; 77,560 acres are presently in forest (including some areas of non-forested land); 9,129 acres are in rangeland; and 11,892 acres are in some form of intensive use. According to Appendix VII, Irrigation, 100 acres were irrigated in 1966.

## ESTIMATED FUTURE NEEDS

Determination of needs is made on the basis of multiple-use management and the categories of floodwater damage reduction, watershed protection and rehabilitation measures, and water management contain the practices needed for development under the concept. Development needed in forestry and farming is to keep pace with other needs as the population increases and reach the level required by 2020.

Future needs are given in acres of land to be treated. Intensity or degree of practice application will increase with use. Management practices for enhancement of multiple-use objectives may require several practices on the same acres of land. A partial listing of practices used is given Tables 2-18 and 2-19 in the Puget Sound area section of this Appendix under Means to Satisfy Needs.

Although the Islands are expected to increase in population, this increase will not be rapid enough to necessitate any early action projects. All projects for flood prevention and drainage will occur in later time periods as the need develops. A summation of these projects can be found in the Means to Satisfy Needs section of these Islands.

Very small amounts of urban expansion are expected in the San Juan Islands. The estimated number of acres, according to land use, that will require protective and development measures by the years 1980, 2000, and 2020 are tabulated in Table 13-4. The same land may require more than one of these practices.

**TABLE 13-4. Future needs for watershed management[1]**

| Year | Floodwater Damage[2] Reduction[3] (acres) | Watershed Protection & Rehab.[3] (acres) | Drainage Improvement[3] (acres) | Irrigation Development[3] ment[4] (acres) |
|---|---|---|---|---|
| Cropland | | | | |
| 1980 | 16,024 | 29,129[5] | 9,856 | 500 |
| 2000 | 16,024 | 30,129[5] | 16,427 | 1,000 |
| 2020 | 16,024 | 31,129[5] | 21,903[6] | 4,000 |
| Intensive Land Use | | | | |
| 1980 | 1,270 | 11,892 | 11,892 | 0 |
| 2000 | 1,270 | 11,892 | 11,892 | 0 |
| 2020 | 1,270 | 11,892 | 11,892 | 0 |
| Forested Land[7] | | | | |
| 1980 | 0 | 70,552 | 0 | 0 |
| 2000 | 0 | 69,552 | 0 | 0 |
| 2020 | 0 | 68,552 | 0 | 0 |

1 Acreages derived by map measurements and ADP tabulation for the PS&AW study. Other potential not tabulated. Unrounded figures do not denote accuracy beyond the first three significant figures.

2 Includes overbank flooding of main streams.

3 Needed for full agricultural development (see Appendix V, Water-Related Land Resources, chapter 2, Agriculture).

4 According to Appendix VII, Irrigation, there were 100 acres (using 200 acres feet of water) irrigated in 1966. The Irrigation Appendix projects this figure to remain constant through 2020.

5 Includes 9,129 acres of rangeland.

6 Does not agree with Table 13-3 due to land use changes during time lapse.

7 Includes non-forested land commonly associated with forested areas.

Table 13-5 shows drainage groups in the watersheds of the San Juan Islands, with the acreage of land falling into each group. From this and other data the drainage needs for expected land uses in the Islands are derived.

**TABLE 13-5. Drainage groups in San Juan Islands[1] (in acres)[2]**

| LINE | Watershed Area No.[3] | River Basins and Watersheds | 01 | 02 | 03 | 04 | 05 | 06 | 07 | 08 | 09 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Puget Sound Drainages | | | | | | | | | | | | | | | | | |
| 1 | 0-11 | Orcas-Waldron Island | 1,109 | 55 | 60 | 0 | 0 | 290 | 3,924 | 0 | 701 | 5,176 | 1,512 | 278 | 0 | 0 | 0 | 1 | 13,106 |
| 2 | 0-12 | San Juan (Stewart) Is. | 4,271 | 863 | 76 | 0 | 0 | 318 | 8,222 | 0 | 873 | 3,686 | 1,106 | 739 | 0 | 0 | 0 | 90 | 20,244 |
| 3 | 0-13 | Lopez-Blakely-Decatur Islands | 2,045 | 433 | 223 | 0 | 0 | 67 | 6,144 | 0 | 57 | 4,412 | 1,365 | 352 | 0 | 0 | 0 | 140 | 15,238 |
| 4 | | Total | 7,425 | 1,351 | 359 | 0 | 0 | 675 | 18,290 | 0 | 1,631 | 13,274 | 3,983 | 1,369 | 0 | 0 | 0 | 231 | 48,588 |
| 5 | | Grand Total | 7,425 | 1,351 | 359 | 0 | 0 | 675 | 18,290 | 0 | 1,631 | 13,274 | 3,983 | 1,369 | 0 | 0 | 0 | 231 | 48,588 |

1 Descriptions of drainage groups are found in the Means to Satisfy Needs section of the Area report.

2 Unadjusted measurements, 1966, for Puget Sound Area Study. Tabulations by ADP. Read three significant figures.

3 See Figure 13-1 for location.

# MEANS TO SATISFY NEEDS

Projections indicate that by the year 2020, 5,100 people will reside in these Islands. The means to be used to achieve the levels necessary to meet the needs of this expected population consist of programs and projects for protection and development of the land and water resources found herein. The wise use and development of these resources can supply the spatial needs and aesthetic wants of the growing population in these Islands. The needs as developed in other appendices have been considered in this Appendix as related to the land and water resources of the San Juan Islands.

The objectives of the plan for watershed management are to develop the Islands' resources to achieve their potential production of food and fiber as economically justified; to preserve and enhance fish, wildlife, and recreation values in accord with the Fish and Wildlife and Recreation Appendices, to provide for development of urban areas not subject to floodwater hazard, and to provide spatial needs in keeping with aesthetic qualities of the Area. These objectives will be carried out by various agencies of the Federal and State governments working in close cooperation with each other and with private sources.

## Land Use

Table 13-1 in Present Status indicates present land use. Table 13-6 summarizes by time periods the estimated future use of the lands.

## Flooding

Floodwater damage must be prevented to the extent the hazard remaining does not materially exceed other risks before development is practical. Loss is limited to tolerable levels by restricting intensive use of land in hazardous areas, followed by feasible damage prevention and enhancement measures for suitable land use.

# PLAN OF DEVELOPMENT

This plan to provide for the needs as brought out in the Needs discussion will utilize the program

**TABLE 13-6. Estimated future land use**

| Year | Crop-land (acres) | Range-land (acres) | Forest[1] (acres) | Urban Built-up[2] (acres) | Fresh water (acres) | Total (acres) |
|---|---|---|---|---|---|---|
| 1980 | 20,000 | 9,129 | 70,552 | 11,892 | 955 | 112,528 |
| 2000 | 21,000 | 9,129 | 69,552 | 11,892 | 955 | 112,528 |
| 2020 | 22,000 | 9,129 | 68,552 | 11,892 | 955 | 112,528 |

1 Includes non-forested land normally associated with forest.

2 Rural non-farm is assumed to be all urban by 1980. Built-up is based on average urban density of six persons per acre.

and project approach, as explained in the Puget Sound Area section. The plan will guide the development of the resources of the San Juan Islands to provide for spatial and production requirements for the expected population of its service area to the year 2020. The Islands offer few opportunities for projects and programs to maintain or increase fish and wildlife, however, a number of opportunities exist for the development of facilities to meet recreation demands. No projects are deemed necessary until after 1980.

## Projects after 1980

Several projects will be initiated in the 1980-2000 time period to remedy existing floodwater and drainage conditions and to develop lands toward their potential for continued use. Benefits and benefit-cost ratios have not been computed for projects past 1980. Table 13-7 gives brief summaries of projects included in this plan:

**TABLE 13-7. Costs of projects recommended for installation after 1980**

| Watershed Area No. and Name[1] | Project Area (acres) | Struc. Meas. Installation Cost[2] (dollars) |
|---|---|---|
| 0-11 Orcas-Waldron Islands | 46,343 | 486,000 |
| 0-12 San Juan Island | 39,103 | 1,320,000 |
| 0-13 Lopez-Blakely-Decatur | 26,127 | 930,000 |
| TOTAL | 111,573 | 2,736,000 |

[1] See Figure 13-1 for location.

[2] 1967 prices.

## Programs

Program measures refer to on-farm and urban on-site practices which take advantage of improvements made possible by the structural works of improvement, as well as measures for watershed protection, erosion control, and water management. These measures will include seeding of improved grasses and legumes, cover crops, cropland and urban drainage development made possible by structural works of improvement, forest management practices, and irrigation development.

Table 13-8 shows a breakdown of the various practices for each of the three time periods.

## Summary of Costs

Costs for the San Juan Islands' plan (project costs plus program costs, rounded to the nearest thousand dollars) are expected to be $11,897,000 for the early action program; $16,725,000 for the years 1980-2000; and $13,720,000 for the years 2000 through 2020. Total cost of the plan will be $42,342,000. See page 2-89 et seq. for further explanation of costs.

**TABLE 13-8. Watershed management practices for protection and development, by time periods, San Juan Islands**

| Practice | Area (acres) | | Cost[1] (thousands of dollars) |
|---|---|---|---|
| **First 15 Years** | | | |
| Technical assistance & management | 99,681[2] | | 2,134 |
| Federal, regular | | 2,134 | |
| Federal, accelerated | | 0 | |
| Installation of practices (non-Federal) | | | 9,763 |
| State & corporate management | | 990 | |
| Land treatment | 87,824 | 1,594 | |
| Water management | 9,856 | 1,828 | |
| Urban drainage | 3,964 | 5,351 | |
| Total | | | 11,897 |
| **1980-2000** | | | |
| Technical assistance & management | 99,681[2] | | 3,006 |
| Federal, regular | | 2,871 | |
| Federal, accelerated | | 135 | |
| Installation of practices (non-Federal) | | | 10,983 |
| State & corporate management | | 1,321 | |
| Land treatment | 87,824 | *2,126 | |
| Water management | 12,047 | *2,436 | |
| Urban drainage | 3,778 | *5,100 | |
| Total | | | 13,989 |
| **2000-2020** | | | |
| Technical assistance & management | 99,681[2] | | 2,871 |
| Federal, regular | | 2,871 | |
| Federal, accelerated | | 0 | |
| Installation of practices (non-Federal) | | | 10,849 |
| State & corporate management | | 1,321 | |
| Land treatment | 87,824 | *2,126 | |
| Water management | 3,000 | *1,800 | |
| Urban drainage | 4,150 | *5,602 | |
| Total | | | 13,720 |

[1] Base: 1967 prices, except items asterisked are 1967 adjusted normalized prices. (See page 2-89 et seq.)

[2] Total acres in Islands involved in program measures.

# EXHIBIT 1

## SOIL AND LAND USE INTERPRETATIONS
## FOR
## WATERSHED MANAGEMENT

Prepared for

**COMPREHENSIVE WATER AND RELATED LAND RESOURCE STUDY**
**OF**
**PUGET SOUND AND ADJACENT WATERS**

By

**SOIL CONSERVATION SERVICE**
**UNITED STATES DEPARTMENT OF AGRICULTURE**

June 1969

# SOIL AND LAND USE INTERPRETATIONS FOR WATERSHED MANAGEMENT

## CONTENTS



## TABLES

# CONTENTS—Continued



# FIGURES

# EXHIBIT I

# SOIL AND USE INTERPRETATIONS FOR WATERSHED MANAGEMENT

## INTRODUCTION

The economy of the Puget Sound Area is rapidly expanding, causing demands on the water supply, changes in land use, and other alterations of the land to meet the requirements of the populace. People require water for their many enterprises and activities, such as supplying municipal and industrial needs, power, transportation, irrigation, and habitat for fish and wildlife. People also need land for production of food and fiber and as space for living, for recreation, and other purposes. The land must receive the precipitation, store and release the water to provide streamflow and supply water for many other uses.

The purpose of these interpretations is to provide information for judging the suitability of soils for various land uses. The varied needs for land can be met with good planning if the available supply and kind of land is allocated to the purpose, or range of purposes, for which it is best adapted. Low, fertile areas are usually best suited for cropland, and often poorly suited for intensive development; while many terrace areas less suitable for crop production provide the stability and good drainage needed for urban development. The higher forested areas, in turn, best provide water supply, recreation, and the products of the forest.

Developments of an urban, or urban-related nature have a large impact on the environment and in future years must be located and installed with more care than has been evidenced, frequently, in the past.

Not all decisions pertaining to development appear large at first. Most cities start with only a few developments. The big effects on the environment are very apt to be the aggregate of many, deceptively small, developments.

People, in their search for the good life in new suburban areas, find too often their septic tanks are unreliable; that the foundations of their houses crack or disintegrate; or that basements are subject to dampness or flooding during wet weather. Oftentimes, streets, schools, and other public services are difficult to operate and maintain, causing unanticipated increases in taxes and assessments.

Many of the difficulties could be avoided by careful initial planning of such developments and by adequate financing of the public services to be furnished. The best planning begins with a careful choice of site to minimize inherent difficulties caused by soil and water conditions. Failure to provide good planning and adequate financial resources for development may result in large economic losses, not only to the individuals directly concerned, but to the public at large.

Adequate land suitable for urban-oriented development is available in the Puget Sound Area. The tables included here are intended to give preliminary aid in selecting sites for a variety of purposes and to help in evaluating the difficulties that may be anticipated in development. Many variations in soil conditions exist, and these tables are intended to aid in preliminary site selection and evaluation only. Because of the limitations in delineating on a map conditions that may vary within a short distance, each site considered should be further investigated through on-site tests before final selection is made and before design of a structure is undertaken.

For purposes of this study, a map was prepared to show the general location and area covered by the different soil series, grouped by soil associations. Soil mapping units are shown on the more detailed county soil survey maps. Copies of the National Cooperative Soil Survey reports by counties are generally available at public libraries and at field offices of the United States Department of Agriculture, and should be used for consideration of specific locations.

It should be pointed out that determinations of soil properties are made only for typical soils and estimated as representative of larger groups for the purpose of general interpretations. Specific sites or soil bodies may show moderate variations from the values shown on the tables which follow.

Measurement of quadrangle maps of the Puget Sound Area by the United States Geological Survey determined the area of land and fresh water to be 8,547,220 acres. However, for this report, it was necessary to measure the Cooperative Soil Survey maps by counties to determine areas of soils by series for use in soil interpretations, and to measure aerial photographs to determine the acreages for the generalized land use categories of cropland, rangeland, forest, rural non-farm, urban built-up, and fresh water. Measurements were made by polar planimeter and compiled by automatic data processing.

The total area obtained by these measurements is 8,556,773 acres, a small deviation from the total derived by the U. S. Geological Survey. Other differences may be found at the basin levels; however, the results are deemed adequate for planning purposes, and no attempt has been made to factor the many component measurements to produce reconciled figures. In general, acreages have not been rounded and, in lieu of rounding, should be regarded as probably accurate to the third significant figure.

# LAND USE AND OWNERSHIPS – 1968

## DETERMINATION OF PRESENT LAND USE

To determine how the land of the Puget Sound Area is being used at the present time, the latest aerial photographs (about 1965, scale 1:31,680) were obtained and checked for interpretation and currency by field reconnaissance. These aerial photographs were measured and the acreages tabulated by watersheds and basins. The tabulations included Federally-administered lands, such as national forests and national parks. The acreages are not rounded and it should be recognized that accuracy, being based on cartographic detail as well as planimetry, is less than may be indicated by the exact figures given.

Tables 1 and 2 present acreages for five generalized kinds of land use and fresh water. Table 2 identifies the watershed areas by number within the river basins. Figure 1, Generalized Land Use map, shows these locations. Figure 2, Generalized Ownership map, was compiled from usual sources of record and serves to indicate patterns of ownerships as of 1966.

An attempt was made to tabulate areas by use and not necessarily by land cover. For example, a wooded area used primarily for housing was considered as a built-up area rather than forest. Definitions of the uses tabulated are:

1. **Cropland**—All arable land (land which has been plowed and can be plowed without other preparation) used for production of forage or other agricultural crops.

2. **Rangeland**—Unplowed open land (less than 10 percent forest canopy), usually in native grass species and often tidelands or open prairie-like areas.

3. **Total Forest**—Lands generally having a growth of timber of more than 10 percent canopy, regardless of age or size. These lands include some undifferentiated non-forested areas. Privately-owned areas classed as rural non-agricultural or urban because of density of housing are excluded. Acreages will not agree with classifications made for purposes not based on economic use.

4. **Rural Non-Agricultural**—Farmsteads, rural residences (where there are three or less to 10 acres), riverwash, and mines.

5. **Built-up Area**—Railroads, roadways, airports, residential (where there are more than three dwellings to ten acres), urban, industrial, commercial, cemeteries, etc.

6. **Fresh Water**—Fresh water lakes, ponds, reservoirs, and streams of a size measurable on map scale.

Table 1. Summary of land use by basin in Puget Sound Area (acres) 1/

| Basins | Cropland | Rangeland | Total forest 2/ | Rural non-agricultural | Built-up areas | Fresh water | Total area land and fresh water |
|---|---|---|---|---|---|---|---|
| Nooksack-Sumas | 137,492 | 11,600 | 609,581 | 12,669 | 20,896 | 12,129 | 804,367 |
| Skagit-Samish | 100,465 | 19,748 | 1,753,445 | 20,092 | 18,804 | 35,409 | 1,947,963 |
| Stillaguamish | 34,531 | 1,016 | 385,450 | 5,932 | 6,698 | 4,721 | 438,348 |
| Whidbey-Camano | 23,006 | 2,454 | 84,069 | 12,419 | 10,987 | 719 | 133,654 |
| Snohomish | 71,752 | 2,424 | 1,054,699 | 29,360 | 36,355 | 23,861 | 1,218,451 |
| Cedar-Green | 53,382 | 3,352 | 446,688 | 34,345 | 166,401 | 38,838 | 743,006 |
| Puyallup | 36,853 | 5,683 | 593,339 | 25,729 | 97,446 | 11,297 | 770,347 |
| Nisqually-Deschutes | 45,502 | 43,488 | 506,798 | 19,909 | 19,897 | 10,065 | 645,659 |
| West Sound | 46,215 | 5,137 | 1,123,666 | 64,208 | 42,161 | 12,606 | 1,293,993 |
| Elwha-Dungeness | 23,721 | 2,417 | 409,491 | 5,073 | 5,911 | 1,844 | 448,457 |
| San Juan | 18,594 | 9,129 | 71,958 | 9,118 | 2,774 | 955 | 112,528 |
| Total | 591,513 | 106,448 | 7,039,184 | 238,854 | 428,330 | 152,444 | 8,556,773 |

1/ Unadjusted measurements, 1966, for Puget Sound Area Study, based on National Cooperative Soil Survey maps.

2/ Includes alpine and other non-forested lands normally associated with forest; excludes rural non-agricultural and urban built-up lands.

Table 2. Land use by watershed and basin, Puget Sound Area.
(acres) 1/

| Watershed Areas (by number) | | Cropland | Rangeland | Total Forest 2/ | Rural non-agricultural | Built-up areas | Fresh Water | Total area land and fresh water |
|---|---|---|---|---|---|---|---|---|
| | NOOKSACK-SUMAS BASINS | | | | | | | |
| 10-1 | N. Fork Nooksack River | 2,278 | 579 | 176,174 | 1,352 | 594 | 1,264 | 182,241 |
| 10-2 | M. Fork Nooksack River | 202 | 92 | 62,291 | 225 | 35 | 356 | 63,201 |
| 10-3 | S. Fork Nooksack River | 4,185 | 1,109 | 115,478 | 999 | 407 | 985 | 123,163 |
| 10-4 | Middle Tribs. Nooksack | 7,754 | 322 | 14,250 | 936 | 469 | 1,417 | 25,148 |
| 10-5 | Anderson Creek | 2,241 | 317 | 6,024 | 121 | 86 | | 8,789 |
| 10-6 | Bertrand-Fishtrap Creek | 18,501 | 309 | 3,237 | 716 | 1,151 | 265 | 24,179 |
| 10-7 | Wiser Lake-Tenmile Area | 27,265 | 1,402 | 8,061 | 797 | 780 | 310 | 38,615 |
| 10-8 | Lower Tribs. Nooksack | 14,511 | 387 | 3,269 | 826 | 842 | 1,024 | 20,859 |
| | <u>Nooksack River Basin</u> | 76,937 | 4,517 | 388,784 | 5,972 | 4,364 | 5,621 | 486,195 |
| 11-1 | Upper South Tribs.Sumas | 125 | | 108,837 | 265 | 4 | 247 | 109,478 |
| 11-2 | Saar Creek | 3,512 | 109 | 5,769 | 91 | 129 | | 9,610 |
| 11-3 | Sumas River | 18,287 | 923 | 12,650 | 564 | 655 | 137 | 33,216 |
| | <u>Fraser-Sumas Basins</u> | 21,924 | 1,032 | 127,256 | 920 | 788 | 384 | 152,304 |
| 0-1 | Dakota Creek | 8,270 | 847 | 9,706 | 483 | 1,008 | 52 | 20,366 |
| 0-2 | Coastal Creeks | 4,363 | 768 | 7,681 | 1,705 | 2,185 | 3 | 16,705 |
| 0-3 | Terrell Creek | 5,581 | 620 | 2,773 | 241 | 288 | 438 | 9,941 |
| 0-4 | California Creek | 8,384 | 771 | 4,118 | 392 | 527 | 69 | 14,261 |
| 0-5 | Silver Creek | 5,704 | 419 | 3,479 | 662 | 602 | 139 | 11,005 |
| 0-6 | Squalicum Creek | 4,504 | 1,315 | 7,575 | 779 | 3,063 | 48 | 17,284 |
| 0-7 | Lake Whatcom | 650 | 565 | 30,317 | 673 | 4,630 | 5,198 | 42,033 |
| 0-8 | Chuckanut Mountain | 366 | 183 | 18,217 | 266 | 3,320 | 177 | 22,529 |
| 0-9 | Lummi Island | 809 | 563 | 9,675 | 576 | 121 | | 11,744 |
| | <u>Pacific Drainages</u> | 38,631 | 6,051 | 93,541 | 5,777 | 15,744 | 6,124 | 165,868 |
| <u>TOTAL NOOKSACK-SUMAS BASINS</u> | | 137,492 | 11,600 | 609,581 | 12,669 | 20,896 | 12,129 | 804,367 |
| | SKAGIT-SAMISH BASINS | | | | | | | |
| 9-1 | Upper Skagit River | 1,561 | 3,896 | 692,781 | 3,448 | 669 | 14,130 | 716,485 |
| 9-2 | Baker River | 111 | 246 | 181,676 | 10 | 188 | 6,693 | 188,924 |
| 9-3 | Cascade River | 80 | | 116,508 | 750 | 137 | 1,146 | 118,621 |
| 9-4 | Suiattle River | 50 | 40 | 221,319 | | 166 | 1,762 | 223,337 |
| 9-5 | Sauk River | 775 | 330 | 240,049 | 2,639 | 653 | 2,221 | 246,667 |
| 9-6 | North Skagit Tribs. | 9,882 | 1,063 | 53,562 | 847 | 1,832 | 1,031 | 68,217 |
| 9-7 | South Skagit Tribs. | 2,476 | 641 | 110,815 | 516 | 591 | 2,375 | 117,414 |
| 9-8 | Gages Slough | 7,100 | 1,116 | 1,362 | 2,720 | 2,121 | 335 | 14,754 |
| 9-9 | Nookachamps | 7,480 | 2,593 | 34,740 | 1,668 | 1,096 | 1,461 | 49,038 |
| 9-10 | South Mt. Vernon | 11,500 | 1,520 | 14,881 | 1,788 | 2,443 | 485 | 32,617 |
| | <u>Skagit River Basin</u> | 41,015 | 11,445 | 1,667,693 | 14,386 | 9,896 | 31,639 | 1,776,074 |
| 0-14 | Samish River | 27,737 | 4,195 | 51,765 | 2,089 | 1,896 | 983 | 88,665 |
| | <u>Samish River Basin</u> | 27,737 | 4,195 | 51,765 | 2,089 | 1,896 | 983 | 88,665 |
| 0-10 | Fidalgo Island Group | 3,226 | 109 | 29,153 | 1,597 | 5,204 | 1,010 | 40,299 |
| 0-15 | Skagit Flats | 28,487 | 3,999 | 4,834 | 2,020 | 1,808 | 1,777 | 42,925 |
| | <u>Pacific Drainages</u> | 31,713 | 4,108 | 33,987 | 3,617 | 7,012 | 2,787 | 83,224 |
| <u>TOTAL SKAGIT-SAMISH BASINS</u> | | 100,465 | 19,748 | 1,753,445 | 20,092 | 18,804 | 35,409 | 1,947,963 |
| | STILLAGUAMISH BASIN | | | | | | | |
| 0-17 | N. Fork Stillaguamish | 7,388 | 10 | 170,296 | 1,592 | 1,308 | 1,365 | 181,959 |
| 0-18 | S. Fork Stillaguamish | 3,240 | | 123,933 | 787 | 883 | 777 | 129,620 |
| 0-19 | Jim Creek | 1,233 | | 27,103 | 730 | 241 | 146 | 29,453 |
| 0-20 | Pilchuck Creek | 2,803 | 227 | 44,316 | 793 | 670 | 856 | 49,665 |
| 0-21 | Lower Stillaguamish | 15,436 | 323 | 18,096 | 1,520 | 2,639 | 1,568 | 39,582 |
| 0-22 | Church Creek | 4,431 | 456 | 1,706 | 510 | 957 | 9 | 8,069 |
| | <u>Pacific Drainages</u> | 34,531 | 1,016 | 385,450 | 5,932 | 6,698 | 4,721 | 438,348 |
| <u>TOTAL STILLAGUAMISH BASIN</u> | | 34,531 | 1,016 | 385,450 | 5,932 | 6,698 | 4,721 | 438,348 |

Table 2. Land use by watershed and basin, Puget Sound Area (con.)
(acres) 1/

| Watershed Areas (by number) | Cropland | Rangeland | Total Forest 2/ | Rural non-agricultural | Built-up areas | Fresh Water | Total area land and fresh water |
|---|---|---|---|---|---|---|---|
| WHIDBEY-CAMANO ISLANDS | | | | | | | |
| 0-16 North Island | 9,374 | 679 | 20,220 | 2,276 | 7,923 | 259 | 40,731 |
| 0-23 Camano Island | 2,897 | 539 | 17,966 | 3,183 | 679 | 60 | 25,324 |
| 0-24 Central Island | 5,607 | 1,108 | 19,263 | 3,214 | 1,118 | 76 | 30,386 |
| 0-25 South Island | 5,128 | 128 | 26,620 | 3,746 | 1,267 | 324 | 37,213 |
| Pacific Drainages | 23,006 | 2,454 | 84,069 | 12,419 | 10,987 | 719 | 133,654 |
| TOTAL WHIDBEY-CAMANO ISLANDS | 23,006 | 2,454 | 84,069 | 12,419 | 10,987 | 719 | 133,654 |
| SNOHOMISH BASIN | | | | | | | |
| 8a Snoqualmie River | 20,150 | 420 | 406,867 | 4,287 | 5,087 | 8,875 | 445,686 |
| 8b-1 Skykomish River | 5,806 | 755 | 411,039 | 6,682 | 2,334 | 6,812 | 433,428 |
| 8b-2 Sultan River | 400 | | 68,132 | 246 | 171 | 1,865 | 70,814 |
| 8b-4 Woods Creek | 3,502 | | 35,788 | 983 | 607 | 494 | 41,374 |
| 8-1 Pilchuck River | 7,076 | 40 | 64,056 | 4,277 | 3,005 | 1,830 | 80,284 |
| 8-2 French Creek | 8,328 | 50 | 7,437 | 1,411 | 649 | 190 | 18,065 |
| 8-3 Cathcart Area | 1,911 | | 6,419 | 401 | 166 | 349 | 9,246 |
| 8-4 Snohomish Estuary | 18,029 | 1,114 | 15,809 | 6,066 | 9,204 | 1,997 | 52,219 |
| 8-5 Marshland Area | 5,875 | | 6,776 | 1,302 | 1,010 | 304 | 15,267 |
| Snohomish River | 71,077 | 2,379 | 1,022,323 | 25,655 | 22,233 | 22,716 | 1,166,383 |
| 0-26 Edmonds-Mukilteo | | | 9,613 | 1,428 | 13,445 | 47 | 24,533 |
| 0-33 Tulalip-Warm Beach | 675 | 45 | 22,763 | 2,277 | 677 | 1,098 | 27,535 |
| Pacific Drainages | 675 | 45 | 32,376 | 3,705 | 14,122 | 1,145 | 52,068 |
| TOTAL SNOHOMISH BASIN | 71,752 | 2,424 | 1,054,699 | 29,360 | 36,355 | 23,861 | 1,218,451 |
| CEDAR BASIN | | | | | | | |
| 0-27 Swamp, Bear, North Creeks | 3,863 | 80 | 19,844 | 11,161 | 9,847 | 281 | 45,076 |
| 0-28 Lake Washington | 1,660 | | 16,039 | 3,076 | 61,721 | 22,690 | 105,186 |
| 0-29 Upper West Slope Seattle | | | | | 20,392 | 1,019 | 21,411 |
| 0-30 Sammamish River | 12,084 | 291 | 70,617 | 7,055 | 11,462 | 5,632 | 107,141 |
| 0-31 Cedar River | 2,672 | 749 | 104,141 | 4,087 | 3,094 | 3,266 | 118,009 |
| Pacific Drainages | 20,279 | 1,120 | 210,641 | 25,379 | 106,516 | 32,888 | 396,823 |
| TOTAL CEDAR BASIN | 20,279 | 1,120 | 210,641 | 25,379 | 106,516 | 32,888 | 396,823 |
| GREEN BASIN | | | | | | | |
| 0-34 East Side Green River (Black River) | 14,579 | 1,564 | 34,685 | 6,224 | 17,957 | 2,274 | 77,283 |
| 0-35 West Side Green River (Hill Creek) | 8,940 | 103 | 7,852 | 389 | 14,168 | 952 | 32,404 |
| 0-37 Upper Green River | 9,448 | 535 | 186,821 | 1,404 | 2,150 | 2,620 | 202,978 |
| Green River | 32,967 | 2,202 | 229,358 | 8,017 | 34,275 | 5,846 | 312,665 |
| 0-29 Lower West Slope Seattle | 65 | | 893 | | 15,906 | 63 | 16,927 |
| 0-36 Lakota-Des Moines | 71 | 30 | 5,796 | 949 | 9,704 | 41 | 16,591 |
| Pacific Drainages | 136 | 30 | 6,689 | 949 | 25,610 | 104 | 33,518 |
| TOTAL GREEN RIVER BASIN | 33,103 | 2,232 | 236,047 | 8,966 | 59,885 | 5,950 | 346,183 |

Table 2. Land use by watershed and basin, Puget Sound Area (con.)
(acres) 1/

| | Watershed Areas (by number) | Cropland | Rangeland | Total Forest 2/ | Rural non-agricultural | Built-up areas | Fresh Water | Total area land and fresh water |
|---|---|---|---|---|---|---|---|---|
| | PUYALLUP BASIN | | | | | | | |
| 7-1 | White River | 15,676 | 378 | 285,850 | 4,989 | 7,246 | 5,582 | 319,721 |
| 7-2 | Carbon River | 1,376 | 90 | 84,702 | 684 | 738 | 705 | 88,295 |
| 7-3 | Puyallup River | 11,856 | 1,135 | 133,749 | 8,072 | 14,011 | 2,008 | 170,831 |
| 7-4 | South Prairie Creek | 2,492 | 175 | 52,336 | 560 | 413 | 101 | 56,077 |
| | Puyallup River | 31,400 | 1,778 | 556,637 | 14,305 | 22,408 | 8,396 | 634,924 |
| 0-38 | Hylebos Creek | 1,281 | 177 | 7,239 | 915 | 6,388 | 263 | 16,263 |
| 0-39 | Wapato Creek | 1,699 | 20 | 829 | 1,408 | 2,451 | 100 | 6,507 |
| 0-40 | Fort-Lewis-Tacoma | 2,473 | 3,708 | 28,634 | 9,101 | 66,199 | 2,538 | 112,653 |
| | Pacific Drainages | 5,453 | 3,905 | 36,702 | 11,424 | 75,038 | 2,901 | 135,423 |
| TOTAL | PUYALLUP BASIN | 36,853 | 5,683 | 593,339 | 25,729 | 97,446 | 11,297 | 770,347 |
| | NISQUALLY BASIN | | | | | | | |
| 0-41 | Muck Creek | 9,979 | 15,685 | 41,697 | 1,384 | 1,787 | 344 | 70,876 |
| 0-42 | Horn-Tanwax Creeks | 4,433 | 4,052 | 24,457 | 572 | 292 | 819 | 34,625 |
| 0-43 | Ohop Creek | 2,009 | 85 | 24,720 | 469 | 321 | 439 | 28,043 |
| 0-44 | Mashel River | 560 | 545 | 52,327 | 220 | 548 | 34 | 54,234 |
| 0-45 | Nisqually River | 12,273 | 13,641 | 236,474 | 3,723 | 2,533 | 5,832 | 274,476 |
| | Pacific Drainages | 29,254 | 34,008 | 379,675 | 6,368 | 5,481 | 7,468 | 462,254 |
| TOTAL | NISQUALLY BASIN | 29,254 | 34,008 | 379,675 | 6,368 | 5,481 | 7,468 | 462,254 |
| | DESCHUTES BASIN | | | | | | | |
| 0-46 | Deschutes River | 6,650 | 6,466 | 76,276 | 2,348 | 4,308 | 817 | 96,865 |
| 0-47 | Henderson Inlet Area | 8,524 | 2,109 | 36,281 | 8,426 | 7,164 | 1,497 | 64,001 |
| 0-48 | West Budd Inlet Area | 1,074 | 905 | 14,566 | 2,767 | 2,944 | 283 | 22,539 |
| | Pacific Drainages | 16,248 | 9,480 | 127,123 | 13,541 | 14,416 | 2,597 | 183,405 |
| TOTAL | DESCHUTES BASIN | 16,248 | 9,480 | 127,123 | 13,541 | 14,416 | 2,597 | 183,405 |
| | WEST SOUND BASINS | | | | | | | |
| 0-56 | S. Fork Skokomish River | 1,900 | 40 | 79,607 | 80 | 294 | 313 | 82,234 |
| 0-57 | N. Fork Skokomish River | 70 | 40 | 69,199 | 450 | 82 | 4,355 | 74,196 |
| | Skokomish River | 1,970 | 80 | 148,806 | 530 | 376 | 4,668 | 156,430 |
| 0-49 | Skookum Creek | 3,363 | 200 | 46,160 | 3,532 | 1,046 | 531 | 54,832 |
| 0-50 | Isabella Creek | 821 | | 18,019 | 2,256 | 806 | 338 | 22,240 |
| 0-51 | Anderson Island | 607 | | 4,205 | 216 | 4 | 143 | 5,175 |
| 0-52 | McNeil Island | 1,268 | | 2,760 | 88 | 101 | 115 | 4,332 |
| 0-53 | Hartstene Island | 450 | | 11,530 | 1,617 | | | 13,597 |
| 0-54 | Goldsborough Creek | 907 | 89 | 34,599 | 370 | 2,536 | 274 | 38,775 |
| 0-55 | Northwest Shelton | 1,724 | 130 | 90,409 | 8,639 | 1,699 | 2,421 | 105,022 |
| 0-58 | West Hood Canal | | | 27,938 | 2,188 | 282 | 177 | 30,585 |
| 0-59 | Tahuya River | 70 | | 27,237 | 794 | 198 | 491 | 28,790 |
| 0-60 | North Hood Canal | 621 | | 28,170 | 2,815 | 1,233 | 362 | 33,201 |
| 0-62 | Carr Inlet Area | 4,287 | 460 | 60,524 | 10,616 | 3,933 | 389 | 80,209 |
| 0-63 | Vashon Island | 3,870 | 543 | 15,368 | 2,400 | 918 | 6 | 23,105 |
| 0-66 | Hamma Hamma River | | | 59,096 | 310 | 58 | 248 | 59,712 |
| 0-67 | Dosewallips-Duckabush | 241 | 8 | 144,111 | 1,642 | 131 | 275 | 146,408 |
| 0-68 | East Hood Canal | 178 | | 51,267 | 1,953 | 443 | 328 | 54,169 |
| 0-69 | West Kitsap Area | 4,649 | 386 | 53,216 | 4,861 | 13,226 | 483 | 76,821 |
| 0-70 | East Kitsap Area | 7,614 | 1,138 | 68,242 | 10,907 | 7,219 | 527 | 95,647 |
| 0-71 | Quilcene | 967 | 55 | 75,088 | 1,335 | 200 | 225 | 77,870 |
| 0-72 | East Jefferson | 3,667 | 1,197 | 109,185 | 5,578 | 6,539 | 463 | 126,629 |
| 0-73 | Chimacum | 4,257 | 226 | 16,981 | 398 | 464 | 108 | 22,434 |
| 0-75 | Sequim Bay Area | 745 | 15 | 20,906 | 637 | 156 | 23 | 22,482 |
| 0-76 | Johnson Creek | 3,939 | 610 | 9,849 | 526 | 593 | 11 | 15,528 |
| | Pacific Drainages | 44,245 | 5,057 | 974,860 | 63,678 | 41,785 | 7,938 | 1,137,563 |
| TOTAL | WEST SOUND BASINS | 46,215 | 5,137 | 1,123,666 | 64,208 | 42,161 | 12,606 | 1,293,993 |

AD-A037 582 PACIFIC NORTHWEST RIVER BASINS COMMISSION VANCOUVER WASH F/G 8/6
COMPREHENSIVE STUDY OF WATER AND RELATED LAND RESOURCES. PUGET --ETC(U)
MAR 70 A T NEALE, S STEINBORN, L F KEHNE

UNCLASSIFIED NL

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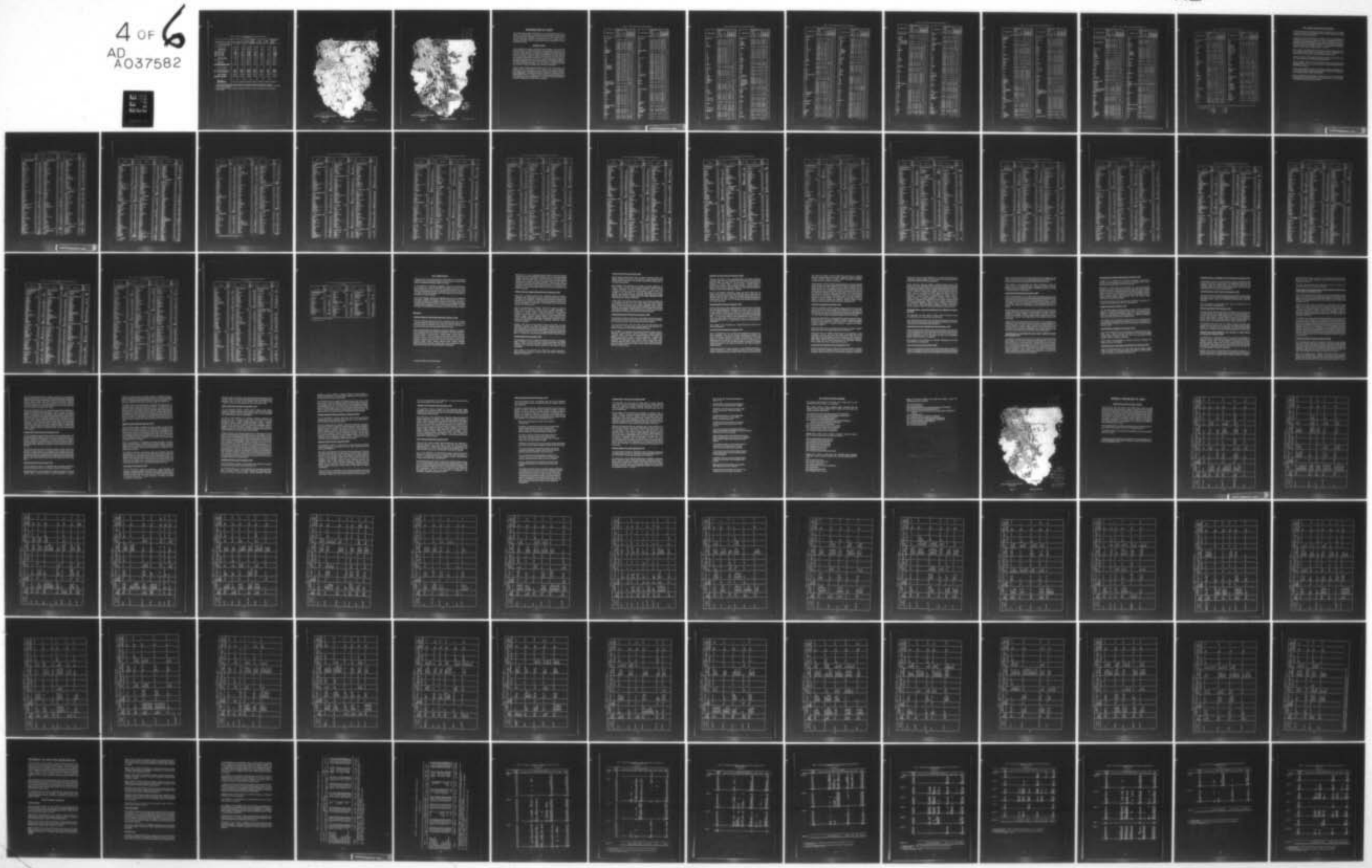

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Table 2. Land use by watershed and basin, Puget Sound Area (con.)
(acres) 1/

| Watershed Areas (by number) | Cropland | Rangeland | Total Forest 2/ | Rural non-agricultural | Built-up areas | Fresh Water | Total area land and fresh water |
|---|---|---|---|---|---|---|---|
| ELWHA-DUNGENESS BASINS | | | | | | | |
| 0-77 Dungeness River | 14,936 | 975 | 119,500 | 2,266 | 967 | 361 | 139,005 |
| Dungeness River | 14,936 | 975 | 119,500 | 2,266 | 967 | 361 | 139,005 |
| 0-78 McDonald Creek | 1,955 | 241 | 13,580 | 103 | 74 | 4 | 15,957 |
| 0-79 Siebert Creek | 2,100 | 210 | 12,435 | 196 | 136 | 2 | 15,079 |
| 0-80 Morse Creek | 2,402 | 475 | 41,780 | 1,185 | 411 | 55 | 46,308 |
| 0-81 Ennis Creek | 152 | 180 | 5,193 | 199 | 352 | 8 | 6,084 |
| 0-82 Port Angeles | 1,424 | 232 | 10,062 | 892 | 3,630 | 8 | 16,248 |
| Pacific Drainages | 8,033 | 1,338 | 83,050 | 2,575 | 4,603 | 77 | 99,676 |
| 0-83 Elwha River | 752 | 104 | 206,941 | 232 | 341 | 1,406 | 209,776 |
| Elwha River | 752 | 104 | 206,941 | 232 | 341 | 1,406 | 209,776 |
| TOTAL ELWHA-DUNGENESS BASINS | 23,721 | 2,417 | 409,491 | 5,073 | 5,911 | 1,844 | 448,457 |
| SAN JUAN ISLANDS | | | | | | | |
| 0-11 Orcas-Waldron Islands | 3,407 | 2,295 | 36,881 | 3,185 | 575 | 484 | 46,827 |
| 0-12 San Juan (Stewart) Is. | 8,967 | 5,042 | 20,634 | 3,081 | 1,379 | 279 | 39,382 |
| 0-13 Lopez-Blakely-Decatur | 6,220 | 1,792 | 14,443 | 2,852 | 820 | 192 | 26,319 |
| Pacific Drainages | 18,594 | 9,129 | 71,958 | 9,118 | 2,774 | 955 | 112,528 |
| TOTAL SAN JUAN ISLANDS | 18,594 | 9,129 | 71,958 | 9,118 | 2,774 | 955 | 112,528 |
| GRAND TOTAL PUGET SOUND AREA | 591,513 | 106,448 | 7,039,184 | 238,854 | 428,330 | 152,444 | 8,556,773 |

1/ Unadjusted measurements, 1966, for Puget Sound Area Study, based on 1965 aerial photographs. Acreages differ slightly from ownership figures in Table 1-7 of Appendix V, Water Related Land Resources, because of differences in data collection methods.

2/ Includes alpine and other non-forested land normally associated with forest; excludes urban built-up and rural non-farm lands.


**PUGET SOUND AND ADJACENT WATERS**
**STUDY AREA**

0-0 WATERSHED BOUNDARY

**Figure 1.** **Generalized Land Use**


**PUGET SOUND AND ADJACENT WATERS STUDY AREA**

**Generalized Land Ownership**

**Figure 2.**

# DISTRIBUTION OF SOILS

The areal extent and general distribution of soils of the Puget Sound Area, as shown by mapping units on published and unpublished soil survey maps, were measured and tabulated. Data obtained are made available here to planners and others interested in knowing the area of a given soil in a particular watershed. Areas by subwatersheds also are available from the Soil Conservation Service.

## MAPPING UNITS

A soil mapping unit, usually a soil series, type, and phase, is a portion of the landscape that has similar characteristics and qualities and whose limits are fixed by precise definitions. Considering cartographic limitations and the purpose for which the map was made, the soil mapping unit is the area about which the greatest number of precise statements can be made. The soil mapping unit provides the most detailed soils information and is the basis for all interpretive groupings of soils. It furnishes the information needed for developing capability units, forest site groupings, crop suitability groupings, and other interpretive groupings. The most specific management practices and estimates of yields are related to the individual mapping unit.

Table 3, Index of Mapping Units, Puget Sound Area, lists mapping units alphabetically with their range of slope; capability class, subclass, and unit; hydrologic groups; drainage group; woodland group; and wildlife suitability group designations. This table will serve as a reference or guide to the other tables presented here. It provides a means of determining interpretive groups of mapping units that are delineated on county soils maps. Definitions of these group designations are given where applicable.

Table 3. Index of mapping units, Puget Sound Area 1/

| MAPPING UNIT 2/ | Range of Slope in Per-cent | Capability Class | Capability Subclass | Capability Unit | Hydrologic Group | Drainage Group | Woodland Group | Wildlife Suitability |
|---|---|---|---|---|---|---|---|---|
| **ACTIVE DUNE** | | | | | | | | 1 |
| | 3-8 | VIII | es | 38 | B | - | 5 | |
| **AGNEW** | | | | | | | | 2 |
| l | 0-3 | II | sw | 02 | A | 06 | 10 | |
| fsl | 3-8 | II | sw | 02 | A | 06 | 10 | |
| fsl | 15-30 | VI | ew | 23 | A | 06 | 10 | |
| sl | 8-15 | III | ew | 03 | A | 06 | 10 | |
| sl | 15-30 | VI | ew | 23 | A | 06 | 10 | |
| sicl | 3-8 | IV | ws | 13 | A | 06 | 10 | |
| sicl | 15-30 | VI | ew | 23 | A | 06 | 10 | |
| sicl | 30-45 | VII | ew | 32 | A | 06 | 10 | |
| **AGNEW-ELWHA** | | | | | | | | 2 |
| complex | 0-3 | IV | ws | 13 | C | 06 | 10 | |
| **ALDERWOOD** | | | | | | | | 2 |
| l | 3-8 | III | ew | 01 | B | 11 | 3 | |
| l | 15-30 | VI | ew | 21 | B | 07 | 3 | |
| fsl | 3-8 | IV | ew | 22 | B | 11 | 5 | |
| fsl | 8-15 | IV | ew | 22 | B | 11 | 5 | |
| fsl | 15-30 | VI | ew | 21 | B | 11 | 5 | |
| gsl | 0-3 | IV | sw | 09 | B | 11 | 5 | |
| gsl | 3-8 | IV | sw | 09 | B | 11 | 5 | |
| gsl | 3-8 | IV | ew | 22 | B | 11 | 5 | |
| gsl | 8-15 | IV | ew | 22 | B | 11 | 5 | |
| gsl | 15-30 | VI | ew | 21 | B | 11 | 5 | |
| gsl | 30-45 | VII | ew | 30 | B | 11 | 5 | |
| gsl(shallow) | 0-3 | IV | ws | 43 | B | 11 | 10 | |
| gsl(shallow) | 3-8 | IV | ew | 22 | B | 11 | 10 | |
| gsl(shallow) | 8-15 | IV | ew | 22 | B | 11 | 10 | |
| gsl(shallow) | 15-30 | VI | ew | 21 | B | 11 | 10 | |
| gl | 0-3 | III | sw | 09 | B | 11 | 5 | |
| gl | 3-8 | IV | ew | 22 | B | 11 | 5 | |
| gl | 8-15 | IV | ew | 22 | B | 11 | 5 | |
| gl | 15-30 | VI | ew | 21 | B | 11 | 5 | |
| gl | 30-45 | VII | ew | 30 | B | 11 | 5 | |
| stl | 3-8 | VI | ew | 21 | B | 11 | 5 | |
| stl | 8-15 | VI | ew | 21 | B | 11 | 5 | |
| stl | 15-30 | VI | ew | 21 | B | 11 | 5 | |
| ls | 3-8 | VI | ew | 21 | B | 11 | 10 | |
| ls | 15-30 | VI | ew | 21 | B | 11 | 10 | |
| sil | 3-8 | III | ew | 01 | B | 07 | 3 | |
| **ALLUVIAL SOILS** | | | | | | | | 5 |
| Undifferentiated | 0-3 | V | ws | 21 | - | 06 | 16 | |
| Undifferentiated | 0-3 | III | ws | 05 | A | 06 | 16 | |
| **ASTORIA** | | | | | | | | 2 |
| sil | 8-15 | VI | es | 25 | B | - | 3 | |
| sil | 15-30 | VI | es | 25 | B | - | 3 | |
| **AHL** | | | | | | | | 2 |
| vgsil | 30-45 | VII | es | 35 | B | - | 5 | |
| complex | 30-45 | VII | es | 35 | B | - | 5 | |
| r (complex) | 30-45 | VII | es | 36 | B | - | 5 | |
| **BARNESTON** | | | | | | | | 1 |
| gfsl | 0-3 | IV | s | 01 | A | - | 11 | |
| gfsl | 8-15 | IV | s | 01 | A | - | 11 | |
| gfsl | 15-30 | VI | es | 19 | A | - | 11 | |
| gsl | 8-15 | IV | s | 01 | A | - | 7 | |
| gsl | 15-30 | VI | es | 19 | A | - | 7 | |
| stsil | 8-15 | VI | es | 19 | A | - | 11 | |
| gls | 8-15 | VI | se | 17 | A | - | 11 | |
| gls | 15-30 | VI | es | 19 | A | - | 11 | |
| sil | 3-8 | IV | s | 01 | A | - | 4 | |
| sil | 8-15 | IV | es | 06 | A | - | 4 | |
| sil | 15-30 | VI | es | 19 | A | - | 4 | |
| **BARNESTON-WILKESON** | | | | | | | | 1 |
| complex | 15-30 | VI | es | 19 | A | - | 11 | |
| **BARNHARDT** | | | | | | | | 1 |
| gsl | 3-8 | IV | s | 01 | A | - | 7 | |
| gsl | 8-15 | IV | es | 06 | A | - | 7 | |
| gsl | 30-45 | VII | es | 29 | A | - | 7 | |
| gsil | 8-15 | IV | es | 06 | A | - | 7 | |
| gsil | 15-30 | VI | es | 19 | A | - | 7 | |
| **BELFAST** | | | | | | | | 5 |
| fsl | 0-3 | III | ws | 01 | D | 01 | 19 | |
| sl | 0-3 | III | ws | 01 | C | 01 | 19 | |
| sil | 0-3 | III | ws | 01 | D | 01 | 19 | |
| sil | 0-3 | II | ws | 03 | D | 01 | 19 | |

| MAPPING UNIT 2/ | Range of Slope in Per-cent | Capability Class | Capability Subclass | Capability Unit | Hydrologic Group | Drainage Group | Woodland Group | Wildlife Suitability |
|---|---|---|---|---|---|---|---|---|
| **BELLINGHAM** | | | | | | | | 3 |
| l | 0-3 | III | ws | 10 | D | 09 | 16 | |
| fsl | 0-3 | III | ws | 10 | D | 09 | 16 | |
| sil | 0-3 | III | ws | 10 | D | 09 | 16 | |
| sil | 3-8 | III | ws | 10 | D | 01 | 16 | |
| sicl | 0-3 | III | ws | 10 | D | 09 | 16 | |
| sicl | 0-3 | IV | ws | 10 | D | 14 | 16 | |
| sicl | 3-8 | III | ws | 10 | D | 01 | 16 | |
| sic | 0-3 | IV | ws | 10 | D | 14 | 16 | |
| cl | 0-3 | III | ws | 10 | D | 21 | 16 | |
| c | 0-3 | IV | ws | 10 | D | 14 | 16 | |
| **BOW-BELLINGHAM** | | | | | | | | 2 |
| sicl | 3-8 | IV | ws | 11 | D | 09 | - | |
| **BOW** | | | | | | | | 2 |
| l | 0-3 | IV | ws | 11 | D | 10 | 3 | |
| l | 3-8 | IV | ws | 11 | D | 10 | 3 | |
| l | 8-15 | IV | ew | 12 | D | 10 | 3 | |
| l | 15-30 | VI | ew | 28 | D | 10 | 3 | |
| l(shallow) | 0-3 | IV | ws | 11 | D | 10 | 9 | |
| gl | 0-3 | IV | ws | 11 | D | 10 | 3 | |
| gl | 3-8 | IV | ew | 12 | D | 10 | 3 | |
| gl | 8-15 | IV | ew | 12 | D | 10 | 3 | |
| gl | 15-30 | VI | ew | 28 | D | 10 | 3 | |
| gl | 30-45 | VII | ew | 31 | D | 10 | 3 | |
| gsil | 0-3 | III | ws | 11 | D | 10 | 9 | |
| gsil | 3-8 | III | we | 16 | D | 10 | 9 | |
| gsil | 15-30 | VI | ew | 28 | D | 10 | 9 | |
| stsil | 3-8 | VI | ew | 28 | D | 10 | 9 | |
| sil | 0-3 | IV | ws | 11 | D | 10 | 9 | |
| sil | 3-8 | IV | ew | 12 | D | 10 | 9 | |
| sil | 8-15 | IV | ew | 12 | D | 10 | 3 | |
| sil | 15-30 | VI | ew | 28 | D | 10 | 3 | |
| sil | 30-45 | VII | ew | 31 | D | 10 | 3 | |
| sil(shallow) | 0-3 | IV | ws | 11 | D | 10 | 9 | |
| sil(shallow) | 3-8 | IV | ws | 11 | D | 10 | 9 | |
| sicl | 3-8 | IV | ew | 12 | D | 10 | 3 | |
| sicl | 8-15 | IV | ew | 12 | D | 10 | 3 | |
| cl | 8-15 | IV | ew | 12 | D | 10 | 9 | |
| cl | 15-30 | VI | ew | 28 | D | 10 | 9 | |
| **BOZARTH** | | | | | | | | 2 |
| fsl | 0-3 | IV | ws | 43 | C | 11 | 10 | |
| fsl | 8-15 | IV | ew | 22 | C | 11 | 10 | |
| **BUCKLEY** | | | | | | | | 3 |
| l | 0-3 | III | ws | 10 | D | 07 | 9 | |
| l | 0-3 | IV | ws | 10 | D | 11 | 9 | |
| sil | 0-3 | III | ws | 10 | D | 07 | 9 | |
| cl | 0-3 | IV | ws | 10 | D | 11 | 9 | |
| **BUCKLEY-ENUMCLAW** | | | | | | | | 3 |
| l | 0-3 | III | ws | 10 | D | 07 | 9 | |
| **CAGEY** | | | | | | | | 2 |
| sl | 3-8 | III | ew | 01 | D | 09 | 6 | |
| gfsl | 0-3 | III | ws | 12 | D | 03 | 6 | |
| gfsl | 3-8 | III | ew | 01 | D | 09 | 6 | |
| gsl | 0-3 | III | ws | 12 | D | 09 | 6 | |
| gsl | 3-8 | III | ew | 01 | D | 09 | 6 | |
| gsl | 8-15 | IV | ew | 22 | D | 09 | 6 | |
| gl | 3-8 | III | ew | 01 | D | 09 | 6 | |
| sil | 3-8 | III | ew | 01 | D | 09 | 6 | |
| sil | 8-15 | IV | ew | 22 | D | 09 | 6 | |
| **CAGEY-NORMA** | | | | | | | | 3 |
| complex | 0-3 | III | ws | 12 | D | 09 | 6 | |
| **CAMAS** | | | | | | | | 6 |
| gl | 0-3 | III | ws | 01 | A | 01 | 7 | |
| cl | 0-3 | II | ws | 03 | A | 01 | 7 | |
| **CARBONDALE** | | | | | | | | 4 |
| muck | 0-3 | II | ws | 06 | D | 03 | 18 | |
| muck(shallow) | 0-3 | IV | ws | 06 | D | 03 | 18 | |
| muck(Snoho.) | 3-8 | IV | ws | 06 | D | 12 | 18 | |
| **CARLSBORG** | | | | | | | | 1 |
| gsl | 0-3 | VI | s | 10 | A | - | 11 | |
| gl | 0-3 | IV | s | 10 | A | - | 11 | |
| **CARSTAIRS** | | | | | | | | 1 |
| gl | 0-3 | VI | s | 21 | A | - | 11 | |
| **CASEY** | | | | | | | | 2 |
| l | 0-3 | IV | ws | 18 | C | 09 | 9 | |

Table 3. Index of mapping units, Puget Sound Area (con) 1/

| MAPPING UNIT 2/ | Range of Slope in Per-cent | Capability | | | Hydrologic Group | Drainage Group | Woodland Group | Wildlife Suitability |
|---|---|---|---|---|---|---|---|---|
| | | Class | Subclass | Unit | | | | |
| CASEY (con) | | | | | | | | 2 |
| l | 8-15 | IV | ew | 12 | C | 09 | 9 | |
| l | 15-30 | VI | ew | 28 | C | 09 | 9 | |
| fsl | 0-3 | IV | ws | 11 | C | 14 | 9 | |
| fsl | 8-15 | IV | ew | 12 | C | 14 | 9 | |
| fsl | 15-30 | VI | ew | 28 | C | 14 | 9 | |
| sil | 0-3 | III | ws | 11 | D | 09 | 9 | |
| CATHCART | | | | | | | | 2 |
| l | 3-8 | III | es | 02 | C | - | 3 | |
| l | 8-15 | IV | es | 09 | C | - | 3 | |
| l | 15-30 | VI | es | 20 | C | - | 3 | |
| l | 30-45 | VII | es | 35 | C | - | 3 | |
| fsl | 3-8 | III | es | 02 | C | - | 5 | |
| gl | 3-8 | IV | es | 09 | C | - | 3 | |
| gl | 8-15 | IV | es | 09 | C | - | 3 | |
| gl | 15-30 | VI | es | 20 | C | - | 3 | |
| gl | 30-45 | VII | es | 35 | C | - | 3 | |
| gsil | 3-8 | III | es | 02 | C | - | 3 | |
| gsil | 15-30 | VI | es | 20 | C | - | 3 | |
| gsil | 30-45 | VII | es | 35 | C | - | 3 | |
| stl | 8-15 | VI | es | 20 | C | - | 5 | |
| stl | 15-30 | VI | es | 20 | C | - | 5 | |
| stl | 30-45 | VII | es | 35 | C | - | 5 | |
| cl | 3-8 | III | es | 02 | C | - | 3 | |
| CHEHALIS | | | | | | | | 5 |
| l | 0-3 | II | ws | 04 | A | 01 | 19 | |
| sil | 0-3 | II | ws | 04 | A | 01 | 19 | |
| sicl | 0-3 | II | ws | 04 | A | 01 | 19 | |
| CHIMACUM | | | | | | | | 1 |
| gl | 3-8 | VI | s | 12 | A | - | 11 | |
| gl | 15-30 | VI | es | 22 | A | - | 11 | |
| gsl | 3-8 | VI | s | 12 | A | - | 11 | |
| gsl | 15-30 | VI | es | 22 | A | - | 11 | |
| vgls | 8-15 | VI | se | 13 | A | - | 11 | |
| vgls | 15-30 | VI | es | 22 | A | - | 11 | |
| CINEBAR | | | | | | | | 1 |
| sil | 0-3 | II | s | 01 | A | - | 3 | |
| CISPUS | | | | | | | | 1 |
| sl (pumicy) | 0-3 | VI | s | 12 | A | - | 15 | |
| CLACKAMAS | | | | | | | | 3 |
| sicl | 0-3 | III | ws | 10 | D | 09 | 16 | |
| CLALLAM | | | | | | | | 2 |
| l | 3-8 | III | ew | 03 | C | 11 | 11 | |
| l | 30-45 | VII | ew | 32 | C | 11 | 11 | |
| gsl | 3-8 | IV | ew | 03 | C | 11 | 10 | |
| gsl | 15-30 | VI | ew | 23 | C | 11 | 10 | |
| gl | 3-8 | III | ew | 03 | C | 11 | 10 | |
| gl | 15-30 | VI | es | 23 | C | - | 10 | |
| CLIPPER | | | | | | | | 3 |
| sicl | 0-3 | III | ws | 10 | C | 06 | 16 | |
| CLOQUALLUM | | | | | | | | 2 |
| l | 3-8 | III | ws | 09 | C | 06 | 9 | |
| sil | 3-8 | IV | ws | 12 | C | 06 | 9 | |
| sil | 8-15 | IV | ew | 14 | C | 06 | 9 | |
| sil | 15-30 | VI | ew | 21 | C | 06 | 9 | |
| sil (shallow) | 8-15 | IV | ew | 14 | C | 06 | 10 | |
| sicl | 8-15 | IV | ew | 14 | C | 10 | 9 | |
| COASTAL BEACH | | | | | | | | 1 |
| | 0-3 | VIII | ew | 39 | A | 01 | - | |
| | 3-8 | VIII | ew | 39 | A | 01 | 15 | |
| COKEDALE | | | | | | | | 5 |
| l | 0-3 | II | ws | 04 | C | 01 | 19 | |
| sl | 0-3 | III | ws | 01 | C | 01 | 19 | |
| sil | 0-3 | II | ws | 04 | C | 01 | 19 | |
| sil/Puyallup | 0-3 | II | ws | 04 | C | 01 | 19 | |
| sicl | 0-3 | III | ws | 03 | C | 06 | 19 | |
| sicl/Puyallup | 0-3 | III | ws | 01 | C | 06 | 19 | |
| CORKINDALE | | | | | | | | 1 |
| l | 0-3 | IV | s | 01 | B | - | 4 | |
| l | 3-8 | IV | es | 06 | B | - | 4 | |
| l | 8-15 | IV | es | 06 | B | - | 4 | |
| l | 15-30 | VI | es | 19 | B | - | 4 | |
| l | 30-45 | VII | es | 29 | B | - | 4 | |
| COLVOS | | | | | | | | 2 |
| fsl | 3-8 | VI | ew | 21 | B | 06 | 2 | |
| COLVOS (con) | | | | | | | | 2 |
| fsl | 15-30 | VI | ew | 21 | B | 06 | 2 | |
| fsl | 30-45 | VII | ew | 30 | B | 06 | 2 | |
| complex | 3-8 | VI | ew | 21 | B | 06 | 2 | |
| complex | 15-30 | VI | ew | 21 | B | 06 | 2 | |
| complex | 30-45 | VII | ew | 30 | B | 06 | 2 | |
| COUPLEVILLE | | | | | | | | 2 |
| l | 0-3 | II | ws | 12 | B | 02 | 19 | |
| sil | 0-3 | II | ws | 12 | B | 02 | 19 | |
| COVELAND | | | | | | | | 2 |
| l | 0-3 | III | ws | 10 | C | 02 | 9 | |
| l | 3-8 | III | ew | 01 | C | 02 | 9 | |
| gl | 0-3 | III | ws | 10 | C | 01 | 9 | |
| gl | 3-8 | III | ew | 01 | C | 01 | 9 | |
| gsil | 0-3 | III | ws | 10 | C | 01 | 9 | |
| gsil | 3-8 | III | ew | 01 | C | 01 | 9 | |
| sil | 0-3 | III | ws | 10 | C | 01 | 9 | |
| sil | 3-8 | III | ew | 01 | C | 01 | 9 | |
| stsil | 8-15 | VI | ew | 28 | C | 02 | 9 | |
| CRESCENT | | | | | | | | 1 |
| gl | 3-8 | IV | s | 01 | B | - | 3 | |
| CUSTER | | | | | | | | 3 |
| fsl | 0-3 | III | ws | 08 | D | 08 | 6 | |
| sl | 0-3 | III | ws | 08 | D | 15 | 6 | |
| sil | 0-3 | III | ws | 08 | D | 08 | 6 | |
| DAYBOB | | | | | | | | 2 |
| vgsl | 3-8 | VI | es | 20 | B | - | 10 | |
| vgsl | 15-30 | VI | es | 20 | B | - | 10 | |
| DELPHI | | | | | | | | 2 |
| gl | 8-15 | III | es | 02 | B | - | 8 | |
| gl | 15-30 | VI | ew | 21 | B | 11 | 8 | |
| DICK | | | | | | | | 1 |
| lfs | 3-8 | III | s | 06 | A | - | 11 | |
| ls | 8-15 | VI | se | 13 | A | - | 11 | |
| ls (complex) | 3-8 | VI | s | 12 | A | - | 5 | |
| DISCOVERY BAY | | | | | | | | 2 |
| gsl | 15-30 | VI | es | 27 | C | - | 5 | |
| gsl | 30-45 | VII | es | 30 | C | - | 5 | |
| gsl (complex) | 15-30 | VI | es | 27 | C | - | 5 | |
| gsl (complex) | 30-45 | VII | ew | 30 | C | 11 | 5 | |
| vgsl (complex) | 15-30 | VII | ew | 30 | A | 11 | 5 | |
| vgsl (complex) | 30-45 | VII | es | 30 | A | - | 5 | |
| vgsl (complex) | + 65 | VIII | es | 37 | A | - | 5 | |
| DUNGENESS | | | | | | | | 5 |
| l | 0-3 | II | ws | 03 | B | 01 | 19 | |
| fsl | 0-3 | II | ws | 03 | B | 01 | 19 | |
| fsl (shallow) | 0-3 | III | ws | 01 | B | 01 | 19 | |
| sil | 0-3 | II | ws | 03 | B | 01 | 19 | |
| DUPONT | | | | | | | | 4 |
| muck | 0-3 | IV | ws | 06 | D | 12 | 18 | |
| EBEYS | | | | | | | | 1 |
| sl | 0-3 | II | sw | 03 | B | 02 | 19 | |
| sl | 3-8 | II | sw | 03 | B | 02 | 19 | |
| EDGEWICK | | | | | | | | 6 |
| vfsl | 0-3 | III | ws | 01 | A | 01 | 17 | |
| fsl | 0-3 | III | ws | 01 | A | 01 | 17 | |
| s | 0-3 | VI | ws | 19 | A | 01 | 15 | |
| sil | 0-3 | II | ws | 03 | A | 01 | 17 | |
| EDMONDS | | | | | | | | 3 |
| l | 0-3 | III | ws | 08 | D | 08 | 6 | |
| fsl | 0-3 | III | ws | 08 | D | 08 | 6 | |
| sl | 0-3 | III | ws | 08 | D | 08 | 6 | |
| ls | 0-3 | IV | ws | 08 | D | 08 | 6 | |
| sil | 0-3 | III | ws | 08 | D | 08 | 6 | |
| ELD | | | | | | | | 5 |
| l | 0-3 | III | ws | 02 | A | 01 | 19 | |
| gl | 0-3 | III | ws | 02 | A | 01 | 19 | |
| sil | 0-3 | III | ws | 01 | A | 01 | 19 | |
| sicl | 0-3 | III | ws | 02 | A | 01 | 19 | |
| ELWHA | | | | | | | | 2 |
| l | 8-15 | IV | ew | 03 | C | 07 | 12 | |
| l | 15-30 | VI | ew | 23 | C | 07 | 12 | |
| ENUMCLAW | | | | | | | | 2 |
| l | 0-3 | III | ws | 12 | B | 07 | 3 | |
| l | 3-8 | III | we | 17 | B | 07 | 3 | |

Table 3. Index of mapping units, Puget Sound Area(con) 1/

| MAPPING UNIT 2/ | Range of Slope in Per-cent | Capability Class | Capability Subclass | Capability Unit | Hydrologic Group | Drainage Group | Woodland Group | Wildlife Suitability |
|---|---|---|---|---|---|---|---|---|
| ENUMCLAW(con) | | | | | | | | 2 |
| fsl | 0-3 | III | ws | 12 | B | 07 | 3 | |
| gsl | 0-3 | III | ws | 12 | B | 07 | 3 | |
| EVERETT | | | | | | | | 1 |
| gl | 0-3 | IV | s | 01 | A | - | 4 | |
| gl | 3-8 | IV | s | 01 | A | - | 4 | |
| gl | 8-15 | IV | s | 01 | A | - | 4 | |
| gsl | 0-3 | VI | s | 18 | A | - | 4 | |
| gsl | 3-8 | VI | s | 18 | A | - | 11 | |
| gsl | 8-15 | VI | se | 17 | A | - | 11 | |
| gsl | 15-30 | VI | es | 19 | A | - | 11 | |
| gsl | 30-45 | VII | es | 29 | A | - | 11 | |
| sl(cobbly) | 0-3 | VI | s | 18 | A | - | 7 | |
| stsl | 0-3 | VII | s | 23 | A | - | 7 | |
| stsl | 8-15 | VII | es | 29 | A | - | 7 | |
| stsl | 15-30 | VII | es | 29 | A | - | 7 | |
| stsl | 30-45 | VII | es | 29 | A | - | 7 | |
| gls | 0-3 | VI | s | 18 | A | - | 11 | |
| gls | 3-8 | VI | s | 18 | A | - | 7 | |
| gls | 8-15 | VI | s | 18 | A | - | 11 | |
| gls | 15-30 | VI | es | 19 | A | - | 11 | |
| stls | 8-15 | VII | es | 29 | A | - | 11 | |
| EVERSON | | | | | | | | 3 |
| fsl | 0-3 | III | ws | 10 | C | 09 | 16 | |
| sil | 0-3 | III | ws | 10 | C | 09 | 16 | |
| cl | 0-3 | IV | ws | 09 | C | 09 | 16 | |
| FIDALGO | | | | | | | | 2 |
| rl | 8-15 | VI | es | 27 | C | - | 3 | |
| rl | 15-30 | VI | es | 27 | C | - | 3 | |
| rl | 30-45 | VII | es | 35 | C | - | 3 | |
| FITCH | | | | | | | | 1 |
| gsl | 0-3 | VI | s | 01 | A | - | 11 | |
| gsl | 3-8 | VI | s | 01 | A | - | 11 | |
| gsl | 8-15 | VI | s | 19 | A | - | 11 | |
| gsl | 15-30 | VI | es | 19 | A | - | 11 | |
| FRESH WATER MARSH | | | | | | | | 4 |
| | 0-3 | VIII | ws | 22 | A | 01 | 18 | |
| GALVIN | | | | | | | | 3 |
| sil | 0-3 | III | ws | 09 | C | 09 | 5 | |
| sicl | 0-3 | III | ws | 09 | C | 09 | 5 | |
| GILES | | | | | | | | 1 |
| l | 0-3 | III | s | 08 | B | - | 2 | |
| l | 3-8 | III | es | 02 | B | - | 2 | |
| l | 8-15 | IV | es | 09 | B | - | 2 | |
| l | 15-30 | VI | es | 20 | B | - | 2 | |
| fsl | 0-3 | III | s | 08 | B | - | 2 | |
| fsl | 8-15 | IV | es | 09 | B | 06 | 2 | |
| fsl | 15-30 | VI | es | 20 | B | - | 2 | |
| sil | 0-3 | II | s | 01 | B | - | 2 | |
| sil | 3-8 | II | s | 01 | B | - | 2 | |
| sil | 8-15 | IV | es | 09 | B | - | 2 | |
| sil(g subsoil) | 3-8 | III | s | 08 | B | - | 2 | |
| sil(g subsoil) | 15-30 | VI | es | 20 | B | - | 2 | |
| GILES-TROMP | | | | | | | | 1 |
| | 0-3 | III | ws | 08 | B | 06 | 2 | |
| GILLIGAN | | | | | | | | 1 |
| l | 0-3 | III | s | 01 | B | - | 5 | |
| gl | 0-3 | III | s | 01 | B | - | 5 | |
| sil | 0-3 | III | s | 01 | B | - | 5 | |
| sil(shallow) | 0-3 | III | s | 01 | B | - | 5 | |
| GRAVEL PIT | | | | | | | | 1 |
| | 0-3 | VIII | s | 00 | A | - | 7 | |
| GREENWATER | | | | | | | | 1 |
| sl | 0-3 | VI | s | 12 | A | - | 17 | |
| ls | 0-3 | VI | s | 12 | A | - | 17 | |
| ls | 3-8 | VI | s | 12 | A | - | 17 | |
| ls | 8-15 | VI | se | 13 | A | - | 17 | |
| s | 3-8 | VI | s | 12 | A | - | 15 | |
| GREENWOOD | | | | | | | | 4 |
| peat | 0-3 | VIII | ws | 24 | A | 03 | 18 | |
| GROVE | | | | | | | | 1 |
| gsl | 0-3 | VI | s | 14 | A | - | 10 | |
| gsl | 3-8 | VI | s | 14 | A | - | 10 | |
| gsl | 8-15 | VI | se | 15 | A | - | 10 | |

| MAPPING UNIT 2/ | Range of Slope in Per-cent | Capability Class | Capability Subclass | Capability Unit | Hydrologic Group | Drainage Group | Woodland Group | Wildlife Suitability |
|---|---|---|---|---|---|---|---|---|
| GROVE(con) | | | | | | | | 1 |
| gsl | 15-30 | VI | es | 19 | A | - | 10 | |
| gsl | 30-45 | VII | es | 29 | A | - | 10 | |
| gsl(basin) | 0-3 | VI | s | 14 | A | - | 10 | |
| vgsl | 3-8 | VI | s | 14 | A | - | 13 | |
| vgsl | 3-8 | VI | s | 14 | A | - | 10 | |
| vgsl | 15-30 | VI | es | 19 | A | - | 13 | |
| vgsl | 15-30 | VI | es | 19 | A | - | 10 | |
| vgsl | 30-45 | VII | es | 29 | A | - | 13 | |
| gl | 0-3 | IV | s | 01 | A | - | 7 | |
| gl | 8-15 | IV | s | 01 | A | - | 7 | |
| gl(basin) | 0-3 | IV | s | 01 | A | - | 7 | |
| sl(cobbly) | 0-3 | VI | s | 14 | A | - | 13 | |
| sl(cobbly) | 8-15 | VI | se | 15 | A | - | 13 | |
| sl(cobbly) | 15-31 | VI | es | 19 | A | - | 13 | |
| stsl | 0-3 | VI | s | 14 | A | - | 13 | |
| HALE | | | | | | | | 2 |
| sil | 3-8 | III | ws | 08 | C | 09 | 6 | |
| sil | 15-30 | VI | ew | 21 | C | 09 | 6 | |
| HALE-NORMA | | | | | | | | 3 |
| sil | 0-3 | III | ws | 08 | C | 09 | 6 | |
| HARSTINE | | | | | | | | 2 |
| gsl | 8-15 | VI | es | 20 | B | - | 5 | |
| gsl | 15-30 | VI | es | 20 | B | - | 5 | |
| HEISLER | | | | | | | | 2 |
| gl | 3-8 | VI | es | 20 | B | - | 3 | |
| gl | 8-15 | VI | ew | 21 | B | 11 | 3 | |
| gl | 15-30 | VI | ew | 21 | B | 11 | 3 | |
| stl | 15-30 | VI | ew | 21 | B | 11 | 3 | |
| stl | 30-45 | VII | es | 35 | B | - | 3 | |
| l(shaly) | 8-15 | IV | es | 13 | B | - | 3 | |
| l(shaly | 15-30 | VI | ew | 21 | B | 11 | 3 | |
| HEMMI | | | | | | | | 3 |
| sil | 0-3 | III | ws | 11 | C | 09 | 6 | |
| HOODSPORT | | | | | | | | 2 |
| gsl | 0-3 | VI | s | 16 | A | - | 8 | |
| gsl | 8-15 | VI | es | 24 | A | - | 8 | |
| gsl | 15-30 | VI | es | 24 | A | - | 8 | |
| gsl | 30-45 | VII | es | 35 | A | - | 8 | |
| vgsl | 8-15 | VI | es | 24 | A | - | 8 | |
| vgsl | 15-30 | VI | es | 24 | A | - | 8 | |
| stsl | 8-15 | VI | es | 24 | B | - | 8 | |
| stsl | 15-30 | VI | es | 24 | B | - | 8 | |
| HOVDE | | | | | | | | 4 |
| l | 0-3 | VI | ws | 02 | B | 09 | 16 | |
| gsl | 0-3 | V | ws | 21 | B | 09 | 16 | |
| ls | 0-3 | V | ws | 21 | B | 09 | 16 | |
| s | 0-3 | VI | ws | 02 | B | 09 | 16 | |
| sicl | 0-3 | V | ws | 21 | B | 09 | 16 | |
| HOYPUS | | | | | | | | 1 |
| cosl | 0-3 | VI | s | 12 | A | - | 11 | |
| cosl | 8-15 | VI | s | 13 | A | - | 11 | |
| cosl | 15-30 | VI | es | 22 | A | - | 11 | |
| gls | 0-3 | VI | s | 12 | A | - | 11 | |
| gls | 3-8 | VI | s | 12 | A | - | 11 | |
| gls | 8-15 | VI | s | 13 | A | - | 11 | |
| gls | 15-30 | VI | es | 22 | A | - | 16 | |
| gls | 30-45 | VII | es | 34 | A | - | 16 | |
| INDIANOLA | | | | | | | | 1 |
| l | 3-8 | III | s | 01 | A | - | 7 | |
| fsl | 3-8 | IV | s | 01 | A | - | 2 | |
| fsl | 8-15 | IV | se | 05 | A | - | 2 | |
| fsl | 15-30 | VI | es | 19 | A | - | 2 | |
| sl | 0-3 | IV | s | 01 | A | - | 7 | |
| sl | 3-8 | IV | s | 01 | A | - | 7 | |
| sl | 8-15 | IV | se | 05 | A | - | 7 | |
| sl | 15-30 | VI | es | 19 | A | - | - | |
| lfs | 8-15 | IV | se | 05 | A | - | 11 | |
| ls | 0-3 | VI | s | 18 | A | - | 11 | |
| ls | 3-8 | VI | s | 18 | A | - | 11 | |
| ls | 8-15 | IV | se | 05 | A | - | 11 | |
| ls | 15-30 | VI | es | 19 | A | - | 11 | |
| ls | 30-45 | VII | es | 29 | A | - | 11 | |
| sil | 3-8 | IV | s | 01 | A | - | 7 | |

Table 3. Index of mapping units, Puget Sound Area (con) 1/

| MAPPING UNIT 2/ | Range of Slope in Per-cent | Capability Class | Capability Subclass | Capability Unit | Hydrologic Group | Drainage Group | Woodland Group | Wildlife Suitability |
|---|---|---|---|---|---|---|---|---|
| INDIANOLA-ROCHE | | | | | | | | 1 |
| | 3-8 | VI | s | 18 | A | - | 7 | |
| | 8-15 | VI | se | 17 | A | - | 7 | |
| ISSAQUAH | | | | | | | | 5 |
| sil | 0-3 | III | ws | 05 | B | 09 | 16 | |
| JOLLEY | | | | | | | | 2 |
| vgl (correlated with Triton) | 15-30 | VI | es | 19 | B | 11 | 3 | |
| vgl (correlated with Triton) | 30-45 | VII | ew | 30 | B | 11 | 3 | |
| JUNO | | | | | | | | 6 |
| l | 0-3 | VI | ws | 19 | A | 16 | 15 | |
| sl | 0-3 | VI | ws | 19 | A | 01 | 15 | |
| gsl | 0-3 | VI | ws | 19 | A | 16 | 15 | |
| ls | 0-3 | VI | ws | 19 | A | 01 | 15 | |
| KAPOWSIN | | | | | | | | 2 |
| gsl | 3-8 | III | we | 17 | B | 07 | 5 | |
| gsl | 15-30 | VI | ew | 21 | B | 07 | 5 | |
| gl | 0-3 | III | ws | 12 | B | 07 | 3 | |
| gl | 3-8 | III | we | 17 | B | 07 | 3 | |
| gl | 8-15 | IV | ew | 22 | B | 07 | 3 | |
| gl | 15-30 | VI | ew | 21 | B | 07 | 3 | |
| gcl | 3-8 | III | we | 17 | B | 07 | 3 | |
| gcl | 15-30 | VI | ew | 21 | B | 07 | 3 | |
| KEYSTONE | | | | | | | | 1 |
| fsl | 0-3 | VI | s | 12 | A | - | 11 | |
| ls | 0-3 | VI | s | 12 | A | - | 11 | |
| ls | 8-15 | VI | se | 13 | A | - | 11 | |
| ls | 15-30 | VI | es | 22 | A | - | 11 | |
| ls | 30-45 | VII | es | 29 | A | - | 11 | |
| KICKERVILLE | | | | | | | | 1 |
| sil | 3-8 | III | s | 01 | B | - | 3 | |
| sil | 8-15 | IV | es | 06 | B | - | 3 | |
| sil | 15-30 | VI | es | 19 | B | - | 3 | |
| sil | 30-45 | VII | es | 35 | B | - | 3 | |
| KITSAP | | | | | | | | 2 |
| l | 3-8 | III | ew | 01 | C | 06 | 3 | |
| gl | 8-15 | IV | ew | 14 | C | 06 | 9 | |
| gl | 15-30 | VI | ew | 21 | C | 06 | 9 | |
| sil | 0-3 | III | ws | 12 | C | 06 | 3 | |
| sil | 3-8 | III | ew | 01 | C | 06 | 3 | |
| sil | 8-15 | IV | ew | 14 | C | 06 | 3 | |
| sil | 15-30 | VI | ew | 21 | C | 06 | 3 | |
| sil | 30-45 | VII | ew | 30 | C | 06 | 3 | |
| sicl | 0-3 | IV | ws | 12 | C | 06 | 3 | |
| sicl | 8-15 | IV | ew | 14 | C | 10 | 3 | |
| KITSAP-INDIANOLA | | | | | | | | 2 |
| | 8-15 | IV | ew | 14 | C | 06 | 5 | |
| KLABER | | | | | | | | 3 |
| sicl | 0-3 | IV | ws | 11 | D | 14 | 3 | |
| KLAUS | | | | | | | | 1 |
| sl | 0-3 | VI | s | 12 | A | - | 4 | |
| sl | 3-8 | VI | s | 12 | A | - | 4 | |
| sl | 8-15 | VI | s | 13 | A | - | 4 | |
| sl | 15-30 | VI | es | 22 | A | - | 4 | |
| gsl | 0-3 | VI | s | 12 | A | - | 4 | |
| gsl | 3-8 | VI | s | 12 | A | - | 4 | |
| gsl | 8-15 | VI | se | 13 | A | - | 4 | |
| gsl | 15-30 | VI | es | 22 | A | - | 4 | |
| gl | 0-3 | VI | s | 12 | A | - | 4 | |
| gl | 3-8 | VI | s | 12 | A | - | 4 | |
| gl | 8-15 | VI | se | 13 | A | - | 4 | |
| gl | 15-30 | VI | es | 22 | A | - | 4 | |
| KLINE | | | | | | | | 6 |
| l | 0-3 | III | ws | 02 | A | 01 | 3 | |
| l | 3-8 | III | ws | 02 | A | 01 | 3 | |
| sl | 0-3 | IV | ws | 02 | A | 01 | 3 | |
| gl | 0-3 | III | ws | 02 | A | 01 | 3 | |
| gl | 3-8 | III | ws | 02 | A | 01 | 3 | |
| sil | 0-3 | III | ws | 02 | A | 01 | 3 | |
| KOCH | | | | | | | | 5 |
| gsl | 0-3 | IV | ws | 08 | D | 08 | 16 | |
| gl | 0-3 | IV | ws | 08 | D | 08 | 16 | |
| sil | 0-3 | IV | ws | 08 | D | 08 | 16 | |
| KOPIAH | | | | | | | | 3 |
| l | 0-3 | IV | ws | 11 | D | 14 | 3 | |
| sil | 0-3 | IV | ws | 11 | D | 14 | 3 | |
| sicl | 0-3 | IV | ws | 11 | D | 14 | 3 | |
| LA BOUNTY | | | | | | | | 3 |
| sil | 3-8 | III | ws | 12 | C | 09 | 3 | |
| sil | 8-15 | IV | ew | 14 | C | 09 | 3 | |
| sil | 15-30 | VI | ew | 21 | C | 09 | 3 | |
| LA BOUNTY-McKENNA | | | | | | | | 3 |
| complex | 0-3 | III | ws | 10 | C | 09 | 3 | |
| LUMMI | | | | | | | | 5 |
| fsl | 0-3 | II | ws | 04 | C | 06 | 16 | |
| sil | 0-3 | II | ws | 04 | C | 01 | 16 | |
| sicl | 0-3 | III | ws | 03 | C | 06 | 16 | |
| LYNDEN | | | | | | | | 1 |
| l | 0-3 | III | s | 01 | A | - | 2 | |
| l | 3-8 | III | s | 01 | A | - | 2 | |
| sl | 0-3 | VI | s | 18 | A | - | 7 | |
| sl | 3-8 | IV | s | 01 | A | - | 7 | |
| sl | 8-15 | IV | se | 05 | A | - | 7 | |
| sl | 15-30 | VI | es | 19 | A | - | 7 | |
| gsl | 3-8 | IV | s | 01 | A | - | 7 | |
| gsl | 8-15 | IV | se | 05 | A | - | 7 | |
| gl | 0-3 | IV | s | 01 | A | - | 7 | |
| gl | 3-8 | IV | s | 01 | A | - | 7 | |
| ls | 0-3 | VI | s | 18 | A | - | 11 | |
| ls | 3-8 | VI | s | 18 | A | - | 11 | |
| ls | 8-15 | VI | se | 17 | A | - | 11 | |
| ls | 15-30 | VI | es | 19 | A | - | 11 | |
| LYSTAIR | | | | | | | | 1 |
| fsl | 8-15 | IV | se | 05 | A | - | 11 | |
| sl | 3-8 | VI | s | 14 | A | - | 11 | |
| sl | 8-15 | VI | se | 15 | A | - | 11 | |
| sl | 15-30 | VI | es | 19 | A | - | 11 | |
| ls | 3-8 | VI | s | 14 | A | - | 11 | |
| ls | 8-15 | VI | es | 19 | A | - | 11 | |
| MADE LAND | | | | | | | | - |
| | 0-3 | VIII | s | 00 | - | - | - | |
| MARBLEMOUNT | | | | | | | | 2 |
| stl | 15-30 | VI | es | 25 | C | - | 3 | |
| MARSH | | | | | | | | 4 |
| | 0-3 | VIII | ws | 23 | B | 12 | 18 | |
| MAYTOWN | | | | | | | | 5 |
| l | 0-3 | II | ws | 04 | B | 13 | 16 | |
| fsl | 0-3 | III | ws | 03 | B | 13 | 16 | |
| sil | 0-3 | II | ws | 04 | B | 13 | 16 | |
| sicl | 0-3 | II | ws | 04 | B | 13 | 16 | |
| McKENNA | | | | | | | | 3 |
| l | 0-3 | IV | ws | 09 | D | 09 | 16 | |
| l | 8-15 | IV | ew | 12 | D | 09 | 16 | |
| gl | 0-3 | IV | ws | 09 | D | 13 | 16 | |
| gcl | 0-3 | IV | ws | 09 | D | 13 | 16 | |
| sicl | 0-3 | III | ws | 10 | D | 09 | 16 | |
| MUCK (McMurray) | | | | | | | | 4 |
| | 0-3 | IV | ws | 06 | D | 03 | 18 | |
| McMURRAY | | | | | | | | 4 |
| peat | 0-3 | II | ws | 06 | A | 03 | 18 | |
| peat | 0-3 | IV | ws | 06 | A | 03 | 18 | |
| peat (shallow) | 0-3 | IV | ws | 06 | A | 12 | 18 | |
| MELBOURNE | | | | | | | | 2 |
| l | 0-3 | VI | es | 25 | C | - | 3 | |
| l | 3-8 | VI | es | 25 | C | - | 3 | |
| l | 8-15 | IV | es | 16 | C | - | 3 | |
| stl | 15-30 | VI | es | 25 | C | - | 3 | |
| stl | 8-15 | VI | es | 25 | C | - | 3 | |
| sicl | 8-15 | IV | es | 16 | C | - | 3 | |
| sicl | 15-30 | VI | es | 25 | C | - | 3 | |
| sicl | 30-45 | VII | es | 33 | C | - | 3 | |
| MUKILTEO | | | | | | | | 4 |
| peat | 0-3 | II | ws | 06 | A | 03 | 18 | |
| peat | 8-15 | II | ws | 06 | A | 03 | 16 | |
| peat (shallow) | 0-3 | IV | ws | 06 | A | 12 | 18 | |
| NATIONAL | | | | | | | | 1 |
| l (pumicy) | 3-8 | IV | s | 12 | A | - | 17 | |

Table 3. Index of mapping units, Puget Sound Area(con) 1/

| MAPPING UNIT 2/ | Range of Slope in Percent | Capability Class | Capability Subclass | Capability Unit | Hydrologic Group | Drainage Group | Woodland Group | Wildlife Suitability |
|---|---|---|---|---|---|---|---|---|
| **NATIONAL(con)** | | | | | | | | 1 |
| sl(pumicy) | 3-8 | IV | s | 12 | A | - | 17 | |
| **NEPTUNE** | | | | | | | | 6 |
| sl | 0-3 | IV | s | 01 | A | - | 17 | |
| gsl | 3-8 | IV | s | 10 | A | - | 17 | |
| **NESIKA** | | | | | | | | 1 |
| l | 0-3 | III | ws | 12 | B | 01 | 4 | |
| l | 3-8 | III | ew | 01 | B | 01 | 4 | |
| l | 3-8 | IV | es | 07 | B | - | 4 | |
| **NEWBERG** | | | | | | | | 6 |
| l | 0-3 | III | ws | 01 | A | 16 | 17 | |
| fsl | 0-3 | III | ws | 01 | A | 16 | 15 | |
| sl | 0-3 | IV | ws | 02 | A | 16 | 17 | |
| lfs | 0-3 | VI | ws | 19 | A | 16 | 15 | |
| ls | 0-3 | VI | ws | 19 | A | 16 | 15 | |
| sil | 0-3 | II | ws | 03 | A | 16 | 15 | |
| **NISQUALLY** | | | | | | | | 1 |
| s | 3-8 | VI | s | 21 | A | - | 7 | |
| ls | 3-8 | IV | s | 10 | A | - | 7 | |
| ls | 8-15 | IV | se | 11 | A | - | 7 | |
| **NOOKACHAMPS** | | | | | | | | 5 |
| sil | 0-3 | II | ws | 04 | D | 01 | 16 | |
| sicl | 0-3 | II | ws | 04 | D | 01 | 16 | |
| **NOOKSACK** | | | | | | | | 5 |
| fsl | 0-3 | II | ws | 03 | C | 16 | 19 | |
| sil | 0-3 | II | ws | 03 | C | 16 | 19 | |
| **NORDBY** | | | | | | | | 1 |
| l | 3-8 | IV | es | 09 | B | - | 5 | |
| l | 8-15 | IV | es | 09 | B | - | 5 | |
| **NORMA** | | | | | | | | 3 |
| l | 0-3 | III | ws | 09 | C | 06 | 16 | |
| l | 3-8 | III | ws | 09 | C | 06 | 16 | |
| fsl | 0-3 | III | ws | 09 | C | 06 | 16 | |
| sl | 0-3 | III | ws | 09 | C | 06 | 16 | |
| sil | 0-3 | III | ws | 09 | C | 06 | 16 | |
| sil | 3-8 | III | ws | 09 | C | 06 | 16 | |
| sicl | 0-3 | III | ws | 09 | C | 09 | 16 | |
| sic | 0-3 | III | ws | 09 | C | 14 | 16 | |
| cl | 0-3 | III | ws | 09 | C | 06 | 16 | |
| **NORMA-CAGEY** | | | | | | | | 3 |
| complex | 0-3 | III | ws | 09 | C | 09 | 6 | |
| **NORMA-HALE** | | | | | | | | 3 |
| complex | 0-3 | III | ws | 09 | C | 09 | 6 | |
| **NUBY** | | | | | | | | 5 |
| sil | 0-3 | III | ws | 03 | C | 01 | 16 | |
| **OLETE** | | | | | | | | 2 |
| vgsil | 8-15 | VII | es | 35 | C | - | 8 | |
| vgsil | 30-45 | VII | es | 35 | C | - | 8 | |
| vgsil(complex) | 15-30 | VI | es | 27 | C | - | 8 | |
| vgsil(complex) | + 65 | VIII | es | 37 | C | - | 8 | |
| **OLYMPIC** | | | | | | | | 2 |
| stcl | 8-15 | VI | es | 25 | C | - | 5 | |
| stcl | 15-30 | VI | es | 25 | C | - | 5 | |
| stcl | 30-45 | VII | es | 33 | C | - | 3 | |
| sicl | 8-15 | IV | es | 16 | C | - | 3 | |
| sicl | 15-30 | VI | es | 25 | C | - | 3 | |
| **ORCAS** | | | | | | | | 4 |
| peat | 0-3 | VIII | ws | 24 | A | 03 | 18 | |
| peat(shallow over gravel) | 0-3 | VIII | ws | 24 | A | 12 | 18 | |
| **ORTING** | | | | | | | | 2 |
| l | 0-3 | II | ws | 09 | C | 07 | 5 | |
| sl | 0-3 | II | ws | 09 | C | 07 | 5 | |
| gsl | 0-3 | III | ws | 09 | C | 07 | 5 | |
| stsl | 0-3 | IV | ws | 09 | C | 07 | 5 | |
| **OSO** | | | | | | | | 2 |
| l | 3-8 | VI | ew | 21 | B | 11 | 2 | |
| l | 8-15 | VI | ew | 21 | B | 11 | 2 | |
| l | 15-30 | VI | ew | 21 | B | 11 | 2 | |
| l | 30-45 | VII | ew | 30 | B | 11 | 2 | |
| **PICKETT** | | | | | | | | 2 |
| r(complex) | 15-30 | VI | es | 25 | C | - | 5 | |
| r(complex) | 30-45 | VII | es | 35 | C | - | 5 | |
| **PILCHUCK** | | | | | | | | 6 |
| fsl | 0-3 | IV | ws | 01 | A | 16 | 15 | |

| MAPPING UNIT 2/ | Range of Slope in Percent | Capability Class | Capability Subclass | Capability Unit | Hydrologic Group | Drainage Group | Woodland Group | Wildlife Suitability |
|---|---|---|---|---|---|---|---|---|
| **PILCHUCK(con)** | | | | | | | | 6 |
| sl | 0-3 | VI | ws | 19 | A | 16 | 15 | |
| lfs | 0-3 | VI | ws | 19 | A | 01 | 15 | |
| lfs(shallow) | 0-3 | VI | ws | 19 | A | 01 | 15 | |
| ls | 0-3 | VI | ws | 19 | A | 01 | 15 | |
| gls | 0-3 | VI | ws | 19 | A | 16 | 15 | |
| fs | 0-3 | VI | ws | 19 | A | 01 | 15 | |
| gs | 0-3 | VII | ws | 20 | A | 16 | 15 | |
| s | 0-3 | VII | ws | 20 | A | 01 | 15 | |
| **PONDILLA** | | | | | | | | 1 |
| fs | 0-3 | VI | s | 12 | A | - | 11 | |
| **PRATHER** | | | | | | | | 2 |
| sicl | 8-15 | IV | ew | 14 | B | 09 | 3 | |
| sicl | 15-30 | VI | ew | 21 | B | 09 | 3 | |
| sicl | 30-45 | VII | ew | 33 | B | 09 | 3 | |
| **PUGET** | | | | | | | | 5 |
| l | 0-3 | II | ws | 04 | B | 01 | 19 | |
| vfsl | 0-3 | II | ws | 04 | B | 01 | 19 | |
| fsl | 0-3 | II | ws | 04 | B | 01 | 19 | |
| sil | 0-3 | II | ws | 04 | B | 01 | 19 | |
| sicl | 0-3 | II | ws | 04 | B | 01 | 19 | |
| sic | 0-3 | IV | ws | 05 | B | 14 | 16 | |
| cl | 0-3 | II | ws | 04 | B | 01 | 16 | |
| c | 0-3 | IV | ws | 05 | B | 14 | 16 | |
| **PUYALLUP** | | | | | | | | 6 |
| l | 0-3 | II | ws | 03 | B | 01 | 19 | |
| vfsl | 0-3 | II | ws | 03 | B | 16 | 19 | |
| fsl | 0-3 | III | ws | 01 | B | 01 | 17 | |
| fsl | 0-3 | II | ws | 03 | B | 16 | 17 | |
| fsl/Buckley | 0-3 | III | ws | 12 | B | 07 | 19 | |
| sl | 0-3 | III | ws | 01 | B | 01 | 19 | |
| sl/Buckley | 0-3 | III | ws | 03 | B | 07 | 19 | |
| lfs | 0-3 | IV | ws | 02 | B | 16 | 19 | |
| ls | 0-3 | IV | ws | 05 | B | 01 | 17 | |
| sil | 0-3 | II | ws | 03 | B | 01 | 19 | |
| sicl | 0-3 | II | ws | 02 | B | 01 | 19 | |
| **QUILCENE** | | | | | | | | 2 |
| sicl | 8-15 | IV | ew | 14 | C | 11 | 5 | |
| sicl | 15-30 | VI | ew | 21 | C | 11 | 5 | |
| sicl | 30-45 | VII | ew | 30 | C | 11 | 5 | |
| **RAGNAR** | | | | | | | | 1 |
| fsl | 3-8 | IV | s | 12 | A | - | 7 | |
| fsl | 8-15 | IV | se | 13 | A | - | 7 | |
| fsl | 15-30 | VI | se | 13 | A | - | 7 | |
| **REED** | | | | | | | | 3 |
| sicl | 0-3 | IV | ws | 10 | D | 14 | 16 | |
| c | 0-3 | IV | ws | 10 | D | 14 | 16 | |
| **RIFLE** | | | | | | | | 4 |
| peat | 0-3 | II | ws | 06 | A | 03 | 18 | |
| peat(shallow) | 0-3 | IV | ws | 06 | A | 12 | 18 | |
| Bellingham complex | 0-3 | III | ws | 10 | A | 12 | 18 | |
| Bellingham complex | 3-8 | IV | ws | 06 | A | 12 | 18 | |
| **RIVERWASH** | | | | | | | | 6 |
| | 0-3 | VIII | ws | 00 | A | - | 15 | |
| **ROCHE** | | | | | | | | 2 |
| l | 0-3 | III | sw | 09 | D | 07 | 12 | |
| l | 3-8 | III | ew | 01 | D | 07 | 12 | |
| l | 8-15 | IV | ew | 22 | D | 16 | 12 | |
| gsl | 3-8 | III | sw | 09 | D | 07 | 12 | |
| gl | 0-3 | III | sw | 09 | D | 07 | 12 | |
| gl | 3-8 | III | sw | 09 | D | 07 | 12 | |
| gl | 8-15 | IV | ew | 22 | D | 07 | 12 | |
| gl | 15-30 | VI | ew | 21 | D | 07 | 12 | |
| stsl | 8-15 | VI | ew | 21 | D | 07 | 12 | |
| stl | 3-8 | IV | sw | 09 | D | 07 | 12 | |
| stl | 8-15 | IV | ew | 22 | D | 07 | 12 | |
| stl | 15-30 | VI | ew | 21 | D | 07 | 12 | |
| **ROCHE-ROCK** | | | | | | | | 2 |
| complex | 15-30 | VI | es | 27 | D | - | 12 | |
| complex | 30-45 | VII | es | 36 | D | - | 12 | |
| **ROCK LAND** | | | | | | | | 2 |
| | 8-15 | VII | es | 36 | D | - | 12 | |
| | 30-45 | VII | es | 36 | D | - | 12 | |
| **ROUGH BROKEN LAND** | | | | | | | | 2 |
| | 30-45 | VII | es | 36 | A | - | 1 | |

Table 3. Index of mapping units, Puget Sound Area(con) 1/

| MAPPING UNIT 2/ | Range of Slope in Per-cent | Capability Class | Capability Subclass | Capability Unit | Hydrologic Group | Drainage Group | Woodland Group | Wildlife Capability |
|---|---|---|---|---|---|---|---|---|
| ROUGH BROKEN LAND(con) | | | | | | | | 2 |
| | 30-45 | VII | es | 36 | C | - | 2 | |
| | 30-45 | VII | es | 36 | C | - | 5 | |
| | 30-45 | VII | es | 36 | B | - | 10 | |
| ROUGH MOUNTAINOUS | | | | | | | | 2 |
| | 15-30 | VI | es | 25 | C | - | 16 | |
| | 30-45 | VII | es | 36 | A | - | 1 | |
| | 30-45 | VII | es | 36 | C | - | 3 | |
| | 30-45 | VII | es | 36 | B | - | 5 | |
| | 30-45 | VII | es | 36 | B | - | 8 | |
| ROUGH STONY | | | | | | | | 2 |
| | 30-45 | VII | es | 36 | C | - | 2 | |
| SALAL | | | | | | | | 6 |
| fsl | 0-3 | III | s | 08 | B | - | 19 | |
| sil | 0-3 | II | s | 01 | B | - | 19 | |
| SAMISH | | | | | | | | 5 |
| sicl | 0-3 | II | s | 04 | D | 01 | 19 | |
| SAMMAMISH | | | | | | | | 5 |
| sil | 0-3 | III | ws | 05 | B | 06 | 19 | |
| SAN JUAN | | | | | | | | 2 |
| l | 3-8 | III | ws | 04 | B | 11 | 10 | |
| gsl | 3-8 | VI | s | 21 | A | - | 11 | |
| gsl(deep) | 8-15 | IV | es | 11 | B | 11 | 10 | |
| gsl | 15-30 | VI | se | 21 | A | - | 11 | |
| gsl(deep) | 3-8 | III | ws | 04 | B | - | 10 | |
| cosl | 0-3 | VI | s | 21 | A | - | 11 | |
| cosl | 8-15 | VI | s | 21 | A | - | 11 | |
| stsl | 8-15 | VI | se | 21 | A | - | 10 | |
| stsl | 15-30 | VI | se | 21 | A | - | 11 | |
| stl | 15-30 | VI | es | 17 | B | - | 10 | |
| SAUK | | | | | | | | 1 |
| l | 0-3 | III | s | 08 | B | - | 19 | |
| l | 3-8 | III | es | 02 | B | - | 19 | |
| SAXON | | | | | | | | 2 |
| sil | 3-8 | III | es | 02 | B | - | 3 | |
| sil | 8-15 | IV | es | 09 | C | - | 3 | |
| sil | 15-30 | VI | es | 20 | B | - | 3 | |
| SCHNORBUSH | | | | | | | | 2 |
| l | 8-15 | IV | es | 13 | C | - | 3 | |
| l | 15-30 | VI | es | 20 | C | - | 3 | |
| SCHNORBUSH-NORMA | | | | | | | | 2 |
| complex | 8-15 | VI | ew | 21 | C | 16 | 3 | |
| SCHOOLEY | | | | | | | | 3 |
| l | 0-3 | IV | ws | 07 | C | 15 | 16 | |
| SEMIAHMOO | | | | | | | | 4 |
| muck | 0-3 | II | ws | 06 | D | 12 | 18 | |
| muck | 0-3 | II | ws | 06 | D | 03 | 18 | |
| muck(over Mukilteo) | 0-3 | II | ws | 06 | D | 03 | 18 | |
| muck(over Mukilteo) | 0-3 | IV | ws | 06 | A | 03 | 18 | |
| muck(shallow) | 0-3 | IV | ws | 06 | A | 12 | 18 | |
| SEQUIM | | | | | | | | 2 |
| gl | 0-3 | III | ws | 04 | A | 07 | 19 | |
| cl | 0-3 | III | ws | 04 | A | 07 | 19 | |
| SHELTON | | | | | | | | 2 |
| gsl | 3-8 | IV | sw | 09 | B | 11 | 5 | |
| gsl | 8-15 | IV | es | 09 | B | - | 5 | |
| gsl | 15-30 | VI | es | 24 | B | - | 5 | |
| gsl | 30-45 | VII | es | 35 | B | - | 5 | |
| gl | 8-15 | IV | es | 09 | B | - | 3 | |
| SHUMAN | | | | | | | | 5 |
| sicl | 0-3 | II | ws | 04 | A | 01 | 16 | |
| SINCLAIR | | | | | | | | 2 |
| gfsl | 8-15 | IV | ew | 03 | B | 11 | 10 | |
| gfsl | 15-30 | VI | ew | 26 | B | 11 | 10 | |
| gl | 8-15 | IV | ew | 03 | B | 11 | 10 | |
| gl | 15-30 | VI | ew | 26 | B | 11 | 10 | |
| gsl | 3-8 | IV | sw | 06 | B | 11 | 10 | |
| gsl | 15-30 | VI | ew | 26 | B | 11 | 10 | |
| gsl | 30-45 | VII | es | 34 | B | | 10 | |
| l(shotty) | 8-15 | IV | ew | 03 | B | 11 | 10 | |
| l(shotty) | 15-30 | VI | ew | 26 | B | 11 | 10 | |
| cl(shotty) | 3-8 | IV | ew | 03 | B | 11 | 10 | |
| SKAGIT | | | | | | | | 3 |
| sicl | 0-3 | IV | ws | 10 | B | 14 | 16 | |

| MAPPING UNIT 2/ | Range of Slope in Per-cent | Capability Class | Capability Subclass | Capability Unit | Hydrologic Group | Drainage Group | Woodland Group | Wildlife Capability |
|---|---|---|---|---|---|---|---|---|
| SKIYOU | | | | | | | | 2 |
| gl | 3-8 | IV | es | 08 | B | - | 5 | |
| gl | 8-15 | IV | es | 08 | B | - | 5 | |
| gl | 15-30 | VI | ew | 26 | B | 11 | 5 | |
| gl | 30-45 | VII | es | 34 | B | - | 5 | |
| SKOKOMISH | | | | | | | | 5 |
| sil | 0-3 | II | ws | 04 | B | 01 | 19 | |
| SKYKOMISH | | | | | | | | 1 |
| gsl | 3-8 | VI | s | 18 | A | - | 7 | |
| gsl | 8-15 | VI | s | 18 | A | - | 7 | |
| gsl | 15-30 | VI | es | 19 | A | - | 7 | |
| gl | 3-8 | VI | s | 18 | A | - | 7 | |
| sl(cobbly) | 0-3 | VI | s | 18 | A | - | 7 | |
| sl(cobbly) | 3-8 | VI | s | 18 | A | - | 7 | |
| sl(cobbly) | 8-15 | VI | s | 18 | A | - | 7 | |
| sl(cobbly) | 15-30 | VI | es | 19 | A | - | 7 | |
| gs | 3-8 | VII | s | 23 | A | - | 11 | |
| stl | 3-8 | VII | s | 23 | A | - | 7 | |
| sts | 3-8 | VII | s | 23 | A | - | 11 | |
| SMITH CREEK | | | | | | | | 1 |
| gl | 3-8 | IV | s | 01 | A | - | 7 | |
| gl | 15-30 | VI | es | 19 | A | - | 7 | |
| SNAKELUM | | | | | | | | 1 |
| cosl | 0-3 | IV | s | 10 | A | - | 17 | |
| cosl | 8-15 | IV | se | 11 | A | - | 17 | |
| SNOHOMISH | | | | | | | | 5 |
| l | 0-3 | II | ws | 04 | B | 04 | 16 | |
| fsl | 0-3 | II | ws | 04 | B | 04 | 16 | |
| lfs | 0-3 | II | ws | 04 | B | 04 | 16 | |
| sil | 0-3 | II | ws | 04 | B | 04 | 16 | |
| sicl | 0-3 | II | ws | 04 | B | 04 | 16 | |
| sic | 0-3 | II | ws | 04 | B | 04 | 16 | |
| SNOQUALMIE | | | | | | | | 1 |
| gsl | 3-8 | VI | s | 01 | A | - | 4 | |
| gl | 3-8 | IV | s | 01 | A | - | 4 | |
| gls | 3-8 | VI | s | 01 | A | - | 11 | |
| SOL DUC | | | | | | | | 1 |
| gsl | 0-3 | IV | s | 01 | A | - | 1 | |
| gl | 0-3 | IV | s | 01 | A | - | 1 | |
| gl | 8-15 | IV | es | 07 | A | - | 1 | |
| SPALDING | | | | | | | | 4 |
| peat | 0-3 | VIII | ws | 24 | A | 03 | 18 | |
| peat(burned phase) | 0-3 | IV | ws | 06 | A | 03 | 18 | |
| SPANAWAY | | | | | | | | 1 |
| gsl | 0-3 | IV | s | 10 | A | - | 7 | |
| gsl | 3-8 | IV | s | 10 | A | - | 7 | |
| gsl | 8-15 | IV | s | 10 | A | - | 7 | |
| gsl | 15-30 | VI | se | 21 | A | - | 7 | |
| stl | 0-3 | VI | s | 21 | A | - | 7 | |
| stl | 8-15 | VI | s | 21 | A | - | 7 | |
| SQUALICUM | | | | | | | | 2 |
| sil | 8-15 | IV | ew | 14 | B | 09 | 3 | |
| sil | 15-30 | VI | ew | 21 | B | 11 | 3 | |
| sil | 30-45 | VII | ew | 30 | B | 11 | 3 | |
| gsil | 0-3 | IV | sw | 09 | B | 11 | 3 | |
| gsil | 3-8 | IV | ew | 14 | B | 11 | 3 | |
| gsil | 8-15 | IV | ew | 14 | B | 11 | 3 | |
| gsil | 15-30 | VI | ew | 21 | B | 11 | 3 | |
| gsil | 30-45 | VII | ew | 30 | B | 11 | 3 | |
| stsil | 8-15 | IV | ew | 14 | B | 11 | 5 | |
| stsil | 15-30 | VI | ew | 21 | B | 11 | 5 | |
| SQUALICUM-ALDERWOOD | | | | | | | | 2 |
| sil | 8-15 | IV | ew | 14 | B | 11 | 3 | |
| sil | 15-30 | VI | ew | 21 | B | 11 | 3 | |
| stsil | 15-30 | VI | ew | 21 | B | 11 | 5 | |
| STEEP BROKEN LAND | | | | | | | | 2 |
| | 30-45 | VII | es | 36 | B | - | 10 | |
| STOSSEL | | | | | | | | 2 |
| stl | 15-30 | VI | ew | 28 | C | 11 | 9 | |
| cl | 8-15 | IV | ew | 12 | C | 11 | 9 | |
| SULTAN | | | | | | | | 5 |
| l | 0-3 | II | ws | 03 | B | 01 | 19 | |
| fsl | 0-3 | II | ws | 02 | B | 01 | 19 | |
| fsl | 0-3 | II | ws | 03 | B | 01 | 19 | |

Table 3. Index of mapping units, Puget Sound Area(con) 1/

| MAPPING UNIT 2/ | Range of Slope in Per-cent | Capability Class | Capability Subclass | Capability Unit | Hydrologic Group | Drainage Group | Woodland Group | Wildlife Suitability |
|---|---|---|---|---|---|---|---|---|
| SULTAN(con) | | | | | | | | 5 |
| ls | 0-3 | IV | ws | 03 | B | 01 | 17 | |
| sil | 0-3 | II | ws | 03 | B | 01 | 19 | |
| sil | 0-3 | II | ws | 02 | B | 01 | 19 | |
| sil | 3-8 | II | ws | 02 | B | 01 | 19 | |
| sil(shallow) | 0-3 | II | ws | 09 | B | 02 | 19 | |
| cl | 0-3 | II | ws | 02 | B | 01 | 19 | |
| SUMAS | | | | | | | | 5 |
| fsl | 0-3 | II | ws | 02 | C | 01 | 19 | |
| sil | 0-3 | II | ws | 02 | C | 01 | 19 | |
| sicl | 0-3 | II | ws | 02 | C | 01 | 19 | |
| SWANTOWN | | | | | | | | 2 |
| l | 0-3 | IV | ws | 43 | C | 11 | 10 | |
| l | 8-15 | IV | ew | 03 | C | 11 | 10 | |
| gsl | 0-3 | VI | ew | 26 | C | 11 | 10 | |
| gsl | 3-8 | VI | ew | 26 | C | 11 | 10 | |
| gsl | 8-15 | VI | ew | 26 | C | 11 | 10 | |
| gl | 3-8 | IV | ws | 43 | C | 11 | 10 | |
| TACOMA | | | | | | | | 4 |
| muck(shallow) | 0-3 | IV | ws | 06 | B | 12 | 18 | |
| peat | 0-3 | IV | ws | 06 | A | 03 | 18 | |
| TANWAX | | | | | | | | 4 |
| peat | 0-3 | IV | ws | 06 | A | 12 | 18 | |
| TEBO | | | | | | | | 2 |
| l | 8-15 | IV | ew | 16 | C | - | 3 | |
| l | 15-30 | VI | es | 25 | C | - | 3 | |
| gl | 8-15 | VI | es | 25 | C | - | 3 | |
| gl | 15-30 | VI | es | 25 | C | - | 3 | |
| gl | 30-45 | VII | es | 33 | C | - | 3 | |
| TENINO | | | | | | | | 2 |
| gsl | 8-15 | IV | ew | 22 | B | 11 | 7 | |
| gsl | 15-30 | VI | es | 21 | B | - | 7 | |
| THORNTON | | | | | | | | 3 |
| sicl | 0-3 | IV | ws | 10 | D | 14 | 16 | |
| c | 0-3 | IV | ws | 10 | D | 14 | 16 | |
| THORNWOOD | | | | | | | | 1 |
| gsl | 0-3 | VI | s | 18 | A | - | 7 | |
| gsl | 3-8 | VI | s | 18 | A | - | 7 | |
| gsl | 8-15 | VI | se | 17 | A | - | 7 | |
| gsl | 15-30 | VI | es | 19 | A | - | 7 | |
| gl | 0-3 | VI | s | 18 | A | - | 4 | |
| gl | 3-8 | VI | s | 18 | A | - | 4 | |
| gl | 8-15 | VI | es | 19 | A | - | 4 | |
| gl | 15-30 | VI | es | 19 | A | - | 4 | |
| TIDAL MARSH | | | | | | | | 4 |
| | 0-3 | VIII | ws | 23 | B | 16 | 18 | |
| TISCH | | | | | | | | 4 |
| sil | 0-3 | III | ws | 10 | C | 09 | 16 | |
| sicl | 0-3 | III | ws | 10 | C | 09 | 16 | |
| TOKUL | | | | | | | | 2 |
| gsl | 8-15 | IV | es | 08 | A | - | 10 | |
| TOWNSEND | | | | | | | | 2 |
| l | 3-8 | IV | s | 10 | B | - | 10 | |
| fsl | 3-8 | IV | es | 10 | B | - | 10 | |
| sl | 0-3 | IV | s | 10 | B | - | 10 | |
| sl | 8-15 | IV | es | 10 | B | - | 10 | |
| sl | 15-30 | VI | es | 17 | B | - | 10 | |
| gl | 3-8 | IV | se | 10 | B | - | 10 | |

| MAPPING UNIT 2/ | Range of Slope in Per-cent | Capability Class | Capability Subclass | Capability Unit | Hydrologic Group | Drainage Group | Woodland Group | Wildlife Suitability |
|---|---|---|---|---|---|---|---|---|
| TROMP | | | | | | | | 3 |
| fsl | 0-3 | III | ws | 08 | B | 13 | 6 | |
| sil | 0-3 | III | ws | 08 | B | 13 | 6 | |
| sicl | 0-3 | III | ws | 08 | B | 08 | 6 | |
| TROMP-TISCH | | | | | | | | 3 |
| complex | 0-3 | III | ws | 08 | B | 13 | 6 | |
| TROMP-CUSTER | | | | | | | | 3 |
| sil | 0-3 | III | ws | 08 | B | 08 | 6 | |
| TROMP-EDMONDS | | | | | | | | 3 |
| sil | 0-3 | III | ws | 08 | B | 08 | 6 | |
| TROMP-WOODLYN | | | | | | | | 3 |
| sil | 0-3 | III | ws | 08 | B | 08 | 6 | |
| TUMWATER | | | | | | | | 1 |
| fsl | 0-3 | IV | s | 10 | A | - | 7 | |
| lfs | 0-3 | IV | s | 10 | A | - | 7 | |
| lfs | 8-15 | IV | se | 11 | A | - | 7 | |
| lfs | 15-30 | VI | es | 18 | A | - | 7 | |
| WADDELL | | | | | | | | 2 |
| l | 3-8 | III | sw | 09 | C | 06 | 3 | |
| gl | 3-8 | III | sw | 09 | C | 06 | 3 | |
| gl | 8-15 | III | sw | 09 | C | 06 | 3 | |
| sicl | 0-3 | III | ws | 12 | C | 06 | 3 | |
| WAPATO | | | | | | | | 5 |
| sil | 0-3 | III | ws | 05 | C | 05 | 16 | |
| sicl | 0-3 | III | ws | 05 | C | 05 | 16 | |
| cl | 0-3 | III | ws | 05 | C | 05 | 16 | |
| WAPATO-GALVIN | | | | | | | | 5 |
| complex | 0-3 | III | ws | 05 | C | 05 | 16 | |
| WHATCOM | | | | | | | | 2 |
| sil | 3-8 | III | we | 16 | D | 09 | 3 | |
| sil | 8-15 | IV | ew | 12 | D | 09 | 3 | |
| sil | 15-30 | VI | ew | 28 | D | 09 | 3 | |
| sil | 30-45 | VII | ew | 31 | D | 09 | 3 | |
| WHATCOM-McKENNA | | | | | | | | 2 |
| complex | 3-8 | IV | ew | 12 | D | 09 | 3 | |
| WHIDBEY | | | | | | | | 2 |
| gsl | 0-3 | IV | ws | 43 | A | 11 | 8 | |
| gsl | 3-8 | IV | sw | 06 | A | 11 | 8 | |
| gsl | 8-15 | IV | ew | 03 | A | 11 | 8 | |
| gsl | 15-30 | VI | ew | 26 | A | 11 | 8 | |
| WICKERSHAM | | | | | | | | 2 |
| l(shaly) | 0-3 | III | s | 01 | C | - | 4 | |
| l(shaly) | 3-8 | III | s | 01 | C | - | 4 | |
| sil(shaly) | 3-8 | III | es | 02 | C | - | 4 | |
| sil(shaly) | 0-3 | III | s | 01 | C | - | 4 | |
| WILKESON | | | | | | | | 2 |
| l | 8-15 | IV | ew | 14 | B | 09 | 3 | |
| l | 15-30 | VI | ew | 21 | B | 09 | 3 | |
| sil | 8-15 | IV | ew | 14 | B | 09 | 3 | |
| sil | 15-30 | VI | ew | 21 | B | 09 | 3 | |
| WINSTON | | | | | | | | 1 |
| gsl | 0-3 | III | s | 08 | A | - | 11 | |
| WOODINVILLE | | | | | | | | 5 |
| sil | 0-3 | III | ws | 05 | B | 06 | 16 | |
| WOODLYN | | | | | | | | 3 |
| sil | 0-3 | III | ws | 08 | C | 08 | 6 | |

1/ Unadjusted measurements, 1966, for Puget Sound Area Study, based on National Cooperative Soil Survey maps.

2/ Soil symbols used:

| | | | |
|---|---|---|---|
| c | clay | r | rocky |
| co | coarse | s | sandy |
| f | fine | si | silt |
| g | gravelly | st | stony |
| l | loam | v | very |

## SOIL SERIES AND HYDROLOGIC GROUPS

The soil series and the hydrologic groups are summarized by basin acreages in Table 4 and shown by watershed in Table 5. These figures have not been adjusted to agree with USGS totals.

These tables indicate the distribution of significant soils in the Puget Sound Area and may be used in conjunction with soil interpretation tables in considering proposed developments. An important application may be in estimating runoff characteristics as influenced by land cover and treatment, using the charts and methods shown in the Watershed Management Appendix under Effects of Soils and Cover on Runoff.

Soils are put in hydrologic groups on the basis of water intake rates under wet conditions and without the protective effects of vegetation. For convenience, the definitions of hydrologic groups are given here:

Group A—(Lowest runoff potential.) Includes deep sands and gravels with very little silt and clay; also deep, rapidly permeable till.

Group B—Mostly sandy soils, less deep than A; and till less deep or less aggregated than A, but the group as a whole has above-average infiltration after thorough wetting.

Group C—Comprised of shallow soils and soils containing considerable clay and collodial material, though less than those of Group D. The group has below-average infiltration after pre-saturation.

Group D—(Hightest runoff potential.) Includes mostly clays of high-swelling characteristics, but the group also includes some shallow soils with nearly impermeable sub-horizons near the surface.

Table 4. Soil series and hydrologic groups by basin, Puget Sound Area (in acres) 1/

| Soil Series | Hydrologic Group | Acres |
|---|---|---|
| **NOOKSACK-SUMAS BASINS** | | |
| Alderwood | B | 530 |
| Barneston | A | 17,377 |
| Barnhardt | A | 3,361 |
| Belfast | D | 370 |
| Bellingham | D | 4,619 |
| Bow | D | 5,000 |
| Bow-Bellingham | D | 853 |
| Cagey | D | 13,760 |
| Cagey-Norma | D | 516 |
| Carbondale(muck) | D | 3,840 |
| Cathcart | C | 2,600 |
| Clipper | C | 2,018 |
| Coastal Beach | A | 443 |
| Cokedale | C | 326 |
| Custer | D | 8,262 |
| Edmonds | D | 1,270 |
| Edmonds-Tromp | D | 853 |
| Everett | A | 110 |
| Everson | C | 2,268 |
| Fresh Water Marsh | A | 139 |
| Giles | B | 9,160 |
| Giles-Tromp | B | 516 |
| Greenwood(peat) | A | 24 |
| Hale | C | 2,666 |
| Hale-Norma | C | 634 |
| Heisler | B | 1,176 |
| Hemmi | C | 556 |
| Hovde | B | 240 |
| Indianola | A | 1,852 |
| Kickerville | B | 12,865 |
| Klaus | A | 3 |
| Kline | A | 1,734 |
| LaBounty | C | 9,155 |
| LaBounty-McKenna | C | 9,126 |
| Lummi | C | 480 |
| Lynden | A | 14,949 |
| Made Land | - | 248 |
| McKenna | D | 7,839 |
| Melbourne | C | 11 |
| Mukilteo | A | 716 |
| Neptune | A | 991 |
| Nooksack | C | 5,508 |
| Norma | C | 7,417 |
| Norma-Cagey | C | 983 |
| Norma-Hale | C | 388 |
| Pilchuck | A | 4,367 |
| Puget | B | 6,013 |
| Puyallup | B | 21,775 |
| Rifle(Bellingham complex) | A | 35 |
| Rifle(peat) | A | 12,017 |
| Riverwash | A | 1,839 |
| Rough Broken Land | C | 1,038 |
| Rough Mountainous Land | C | 222,619 |
| Rough Stony Land | C | 950 |
| Salal | B | 227 |
| Samish | D | 316 |
| Saxon | B | 741 |
| Schnorbush | C | 1,407 |
| Schnorbush-Norma | C | 276 |
| Semiahmoo | D | 270 |
| Skagit | B | 362 |
| Smith Creek | A | 2,015 |
| Snohomish | B | 832 |
| Squalicum | B | 15,333 |
| Squalicum-Alderwood | B | 7,507 |
| Steep Broken Land | B | 11 |
| Sumas | C | 5,704 |
| Tanwax | A | 39 |
| Thornwood | A | 723 |
| Tidal Marsh | B | 400 |
| Tromp | B | 4,923 |
| Tromp-Custer | B | 1,845 |
| Tromp-Edmonds | B | 249 |
| Tromp-Woodlyn | B | 35 |
| Tumwater | A | 251 |
| Whatcom | D | 32,745 |
| Whatcom-McKenna | D | 8,555 |
| Wickersham | C | 793 |
| Woodlyn | C | 2,522 |
| Water(Fresh) | - | 11,477 |
| Water(Salt) | - | 37,624 |
| Water(Salt)Undistrib. by W.S. | - | 184,932 |
| Total | | 750,519 |

| Soil Series | Hydrologic Group | Acres |
|---|---|---|
| **SKAGIT-SAMISH BASINS** | | |
| Alderwood | B | 26,834 |
| Barneston | A | 1,890 |
| Barnhardt | A | 8 |
| Belfast | D | 780 |
| Bellingham | D | 3,780 |
| Bow | D | 32,492 |
| Cagey | D | -1,026 |
| Cagey-Norma | D | 24 |
| Carbondale(muck) | D | 705 |
| Cathcart | C | 10,056 |
| Clipper | C | 30 |
| Coastal Beach | A | 504 |
| Cokedale | C | 1,938 |
| Cokedale-Puyallup | C | 564 |
| Corkindale | B | 927 |
| Coveland | C | 1,315 |
| Custer | D | 70 |
| Edmonds | D | 80 |
| Everett | A | 10,174 |
| Fidalgo | C | 5,198 |
| Giles | B | 2,294 |
| Gilligan | B | 2,092 |
| Greenwater | A | 3,735 |
| Greenwood(peat) | A | 151 |
| Heisler | B | 1,731 |
| Hovde | B | 39 |
| Indianola | A | 1,650 |
| Kickerville | B | 70 |
| Kitsap | C | 362 |
| Klaus | A | 7,259 |
| Kline | A | 2,407 |
| LaBounty | C | 57 |
| LaBounty-McKenna | C | 18 |
| Lummi | C | 2,465 |
| Lynden | A | 6,041 |
| Made Land | - | 717 |
| Marblemount | C | 60 |
| McKenna | D | 93 |
| Mukilteo | A | 479 |
| Neptune | A | 10 |
| Nookachamps | D | 1,476 |
| Nooksack | C | 70 |
| Norma | C | 1,407 |
| Oso | B | 2,116 |
| Pilchuck | A | 7,513 |
| Puget | B | 27,993 |
| Puyallup | B | 45,424 |
| Puyallup-Puget | B | 225 |
| Rifle(peat) | A | 1,683 |
| Riverwash | A | 3,373 |
| Rough Broken Land | C | 22,890 |
| Rough Mountainous Land | C | 206,929 |
| Rough Stony Land | C | 27 |
| Samish | D | 2,547 |
| Sauk | B | 538 |
| Saxon | B | 432 |
| Saxon | C | 93 |
| Semiahmoo | D | 1,145 |
| Skagit | B | 164 |
| Sklyc[illegible] | B | 7,161 |
| Skykomish | A | 4,144 |
| Snohomish | B | 1,116 |
| Squalicum | B | 8,768 |
| Squalicum-Alderwood | B | 2,217 |
| Sultan | B | 2,723 |
| Sumas | C | 16,438 |
| Tanwax | A | 224 |
| Thornton | D | 1,374 |
| Thornwood | D | 14,500 |
| Tidal Marsh | B | 3,770 |
| Tisch | C | 242 |
| Wickersham | C | 3,928 |
| Woodinville | B | 361 |
| Unclassified | - | 2 |
| Water(Fresh) | - | 14,457 |
| Water(Salt) | - | 43,144 |
| Water(Salt)Undistrib. by W.S. | - | 63,939 |
| Total | | 644,678 |
| **STILLAGUAMISH BASIN** | | |
| Alderwood | B | 28,133 |
| Belfast | D | 70 |
| Bellingham | D | 965 |
| Bow | D | 35 |

| Soil Series | Hydrologic Group | Acres |
|---|---|---|
| Carbondale(muck) | D | 2,142 |
| Cathcart | C | 3,260 |
| Custer | D | 115 |
| Edmonds | D | 909 |
| Everett | A | 14,526 |
| Greenwood(peat) | A | 341 |
| Indianola | A | 6,339 |
| Kitsap | C | 4,506 |
| Klaus | A | 1,435 |
| Kline | A | 60 |
| Lynden | A | 9,950 |
| Made Land | - | 10 |
| Mukilteo | A | 1,759 |
| Norma | C | 2,384 |
| Oso | B | 10,280 |
| Pilchuck | A | 315 |
| Puget | B | 16,105 |
| Puyallup | B | 5,236 |
| Rifle(peat) | A | 1,380 |
| Riverwash | A | 1,548 |
| Rough Broken Land | C | 25,878 |
| Rough Mountainous Land | C | 94,275 |
| Rough Stony Land | C | 5,219 |
| Saxon | B | 735 |
| Saxon | C | 220 |
| Skykomish | A | 17,620 |
| Snohomish | B | 661 |
| Squalicum | B | 525 |
| Sultan | B | 619 |
| Tanwax | A | 10 |
| Tidal Marsh | B | 760 |
| Water(Fresh) | - | 4,435 |
| Water(Salt) | - | 2,183 |
| Water(Salt)Undistrib. by W.S. | - | 3,163 |
| Total | | 268,106 |
| **WHIDBEY-CAMANO** | | |
| Alderwood | B | 12,343 |
| Bellingham | D | 1,350 |
| Bow | D | 2,800 |
| Bozarth | C | 282 |
| Carbondale(muck) | D | 192 |
| Casey | C | 4,109 |
| Coastal Beach | A | 2,042 |
| Coupeville | B | 1,063 |
| Coveland | C | 2,084 |
| Ebeys | B | 651 |
| Everett | A | 2,459 |
| Fresh Water Marsh | A | 73 |
| Greenwood(peat) | A | 99 |
| Hovde | B | 502 |
| Hoypus | A | 18,290 |
| Indianola | A | 3,960 |
| Keystone | A | 15,506 |
| Lummi | C | 1,640 |
| Made Land | - | 675 |
| Mukilteo | A | 925 |
| Norma | C | 2,608 |
| Pondilla | A | 163 |
| Puget | B | 190 |
| Rifle(peat) | A | 770 |
| Rough Broken Land | C | 2,860 |
| Rough Stony Land | C | 271 |
| San Juan | A | 984 |
| Semiahmoo | D | 636 |
| Snakelum | A | 505 |
| Swantown | C | 4,191 |
| Tacoma(peat) | A | 327 |
| Tanwax | A | 493 |
| Tidal Marsh | B | 1,487 |
| Townsend | B | 1,806 |
| Whidbey | A | 44,599 |
| Water(Fresh) | - | 719 |
| Water(Salt)Undistrib.by W.S. | - | 198,297 |
| Total | | 331,951 |
| **SNOHOMISH BASIN** | | |
| Alderwood | B | 146,908 |
| Alluvial soils | A | 911 |
| Barneston | A | 9,402 |
| Bellingham | D | 2,328 |
| Carbondale(muck) | D | 2,489 |
| Cathcart | C | 1,747 |
| Coastal Beach | A | 289 |
| Custer | D | 4,932 |

Table 4. Soil series and hydrologic groups by basin, Puget Sound Area (con)
(in acres) 1/

| Soil Series | Hydrologic Group | Acres |
|---|---|---|
| **SNOHOMISH BASIN(con)** | | |
| Edgewick | A | 4,158 |
| Edmonds | D | 1,507 |
| Everett | A | 61,552 |
| Greenwater | A | 1,125 |
| Greenwood(peat) | A | 1,308 |
| Indianola | A | 2,754 |
| Issaquah | B | 93 |
| Kitsap | C | 12,465 |
| Klaus | A | 15,045 |
| Lynden | A | 14,520 |
| Made Land | - | 305 |
| Marsh | B | 175 |
| Mukilteo | A | 6,806 |
| Nooksack | C | 3,166 |
| Norma | C | 8,613 |
| Oso | B | 4,983 |
| Pilchuck | A | 4,336 |
| Puget | B | 16,160 |
| Puyallup | B | 11,148 |
| Puyallup-Buckley | B | 35 |
| Ragnar | A | 2,029 |
| Rifle(Bellingham complex) | A | 550 |
| Rifle(peat) | A | 5,429 |
| Riverwash | A | 2,311 |
| Rough Broken Land | C | 67,897 |
| Rough Mountainous Land | C | 186,091 |
| Rough Stony Land | C | 18,081 |
| Salal | B | 533 |
| Sammamish | B | 135 |
| Skykomish | A | 11,681 |
| Snohomish | B | 7,710 |
| Snoqualmie | A | 4,733 |
| Stossell | C | 2,093 |
| Sultan | B | 6,672 |
| Tidal Marsh | B | 683 |
| Tokul | A | 4,626 |
| Woodinville | B | 256 |
| Water(Fresh) | - | 15,488 |
| Water(Salt) | - | 16,551 |
| Water(Salt)Undistrib.by W.S. | - | 33,124 |
| Total | | 725,933 |
| **CEDAR BASIN** | | |
| Alderwood | B | 131,609 |
| Alluvial soils | A | 664 |
| Barneston | A | 21,174 |
| Bellingham | D | 1,766 |
| Buckley | D | 12 |
| Carbondale(muck) | D | 1,803 |
| Cathcart | C | 2,708 |
| Coastal Beach | A | 134 |
| Edgewick | A | 33 |
| Edmonds | D | 422 |
| Everett | A | 22,811 |
| Greenwood(peat) | A | 494 |
| Indianola | A | 8,066 |
| Issaquah | B | 312 |
| Kitsap | C | 11,918 |
| Klaus | A | 414 |
| Lynden | A | 2,250 |
| Made Land | - | 178 |
| Marsh | B | 84 |
| Mukilteo | A | 1,162 |
| Norma | D | 5,044 |
| Pilchuck | A | 1,263 |
| Puget | B | 3,029 |
| Puyallup | B | 4,038 |
| Rifle(peat) | A | 4,661 |
| Riverwash | A | 347 |
| Rough Broken Land | C | 8,866 |
| Rough Mountainous Land | C | 31,492 |
| Salal | B | 15 |
| Sammamish | B | 550 |
| Snohomish | B | 411 |
| Snoqualmie | A | 1,905 |
| Sultan | B | 351 |
| Woodinville | B | 211 |
| Unclassified | - | 28,275 |
| Water(Fresh) | - | 30,560 |
| Water(Salt) | - | 18,686 |
| Total | | 347,718 |
| **GREEN BASIN** | | |
| Alderwood | B | 71,057 |
| Alluvial soils | A | 230 |
| Barneston | A | 19,410 |
| Bellingham | A | 447 |
| Buckley | D | 4,132 |
| Carbondale(muck) | D | 1,279 |
| Cathcart | C | 6,572 |
| Coastal Beach | A | 87 |
| Enumclaw | B | 1,961 |
| Everett | A | 11,401 |
| Greenwood(peat) | A | 378 |
| Indianola | A | 2,519 |
| Kitsap | C | 729 |
| Klaus | A | 942 |
| Lynden | A | 320 |
| Made Land | - | 288 |
| Marsh | B | 66 |
| Mukilteo | A | 408 |
| Norma | C | 1,440 |
| Pilchuck | A | 1,157 |
| Puget | B | 3,330 |
| Puyallup | B | 14,179 |
| Puyallup-Buckley | B | 9 |
| Rifle(peat) | A | 2,211 |
| Riverwash | A | 395 |
| Rough Broken Land | C | 11,411 |
| Rough Mountainous Land | C | 47,118 |
| Sammamish | B | 92 |
| Snohomish | B | 755 |
| Snoqualmie | A | 167 |
| Sultan | B | 3,715 |
| Woodinville | B | 494 |
| Unclassified | - | 13,249 |
| Water(Fresh) | - | 5,540 |
| Water(Salt) | - | 29,933 |
| Total | | 257,421 |
| **PUYALLUP BASIN** | | |
| Alderwood | B | 44,582 |
| Alluvial soils | A | 219 |
| Barneston | A | 23,614 |
| Barneston-Wilkeson | A | 2,015 |
| Bellingham | D | 825 |
| Bow | D | 429 |
| Buckley | D | 11,517 |
| Buckley-Enumclaw | D | 1,341 |
| Carbondale(muck) | D | 988 |
| Cathcart | C | 195 |
| Chehalis | A | 110 |
| Coastal Beach | A | 114 |
| Dupont | D | 784 |
| Edgewick | A | 430 |
| Edmonds | D | 185 |
| Enumclaw | B | 7,423 |
| Everett | A | 38,416 |
| Fitch | A | 5,604 |
| Greenwater | A | 3,713 |
| Greenwood(peat) | A | 277 |
| Indianola | A | 5,203 |
| Kapowsin | B | 14,966 |
| Kitsap | C | 2,614 |
| Klaus | A | 503 |
| Kopiah | D | 58 |
| Lynden | A | 44 |
| Made Land | - | 2,011 |
| Marsh | B | 26 |
| McKenna | D | 861 |
| Mukilteo | A | 608 |
| National | A | 1 |
| Newberg | A | 688 |
| Nisqually | A | 589 |
| Norma | C | 699 |
| Orting | C | 2,839 |
| Oso | B | 1,330 |
| Pilchuck | A | 6,687 |
| Puget | B | 492 |
| Puyallup | B | 14,656 |
| Puyallup-Buckley | B | 107 |
| Ragnar | A | 224 |
| Rifle(Bellingham complex) | A | 20 |
| Rifle(peat) | A | 1,111 |
| Riverwash | A | 4,062 |
| Rough Broken Land | C | 55,606 |
| Rough Mountainous Land | C | 94,831 |
| Rough Stony Land | C | 8,810 |
| Semiahmoo | D | 2,021 |
| Sinclair | B | 8,683 |
| Skykomish | A | 215 |
| Snohomish | B | 712 |
| Snoqualmie | A | 267 |
| Spanaway | A | 46,613 |
| Stossell | C | 1,062 |
| Sultan | B | 8,704 |
| Tacoma(muck) | B | 1,701 |
| Tanwax | A | 329 |
| Tidal Marsh | B | 372 |
| Tisch | C | 220 |
| Wapato | C | 6 |
| Wilkeson | B | 20,812 |
| Woodinville | B | 65 |
| Water(Fresh) | - | 10,077 |
| Water(Salt) | - | 19,103 |
| Total | | 483,389 |
| **NISQUALLY BASIN** | | |
| Alderwood | B | 4,637 |
| Barneston | A | 1,448 |
| Barneston-Wilkeson | A | 519 |
| Bellingham | D | 1,335 |
| Bow | D | 131 |
| Carbondale(muck) | D | 88 |
| Cathcart | C | 30 |
| Chehalis | A | 346 |
| Cinebar | B | 596 |
| Cispus | A | 330 |
| Clackamas | D | 140 |
| Delphi | B | 40 |
| Dupont | D | 867 |
| Edmonds | D | 47 |
| Eld | A | 20 |
| Enumclaw | B | 26 |
| Everett | A | 52,417 |
| Everson | C | 1,603 |
| Fitch | A | 4,232 |
| Giles | B | 1,759 |
| Greenwater | A | 3,425 |
| Greenwood(peat) | A | 40 |
| Indianola | A | 2,053 |
| Kapowsin | B | 43,623 |
| Kitsap | C | 1,032 |
| Kleber | D | 362 |
| Kopiah | D | 424 |
| Lynden | A | 1,783 |
| McKenna | D | 3,472 |
| Melbourne | C | 5 |
| Mukilteo | A | 1,076 |
| National | A | 3,170 |
| Nesika | B | 1,893 |
| Newberg | A | 502 |
| Nisqually | A | 3,230 |
| Norma | C | 2,222 |
| Olympic | C | 38 |
| Orting | C | 454 |
| Pilchuck | A | 3,680 |
| Puget | B | 206 |
| Puyallup | B | 2,298 |
| Reed | D | 95 |
| Rifle(peat) | A | 749 |
| Riverwash | A | 999 |
| Rough Broken Land | C | 10,444 |
| Rough Mountainous Land | B | 9,188 |
| Rough Mountainous Land | C | 108,293 |
| Rough Stony Land | C | 2,861 |
| Schooley | C | 348 |
| Semiahmoo | D | 2,875 |
| Sinclair | B | 8,115 |
| Skykomish | A | 271 |
| Snohomish | B | 181 |
| Spanaway | A | 36,022 |
| Stossell | C | 2 |
| Sultan | B | 880 |
| Tacoma(muck) | B | 174 |
| Tanwax | A | 328 |
| Tenino | B | 2,679 |
| Thornwood | A | 50 |
| Tidal Marsh | B | 197 |
| Tisch | C | 1,690 |
| Tromp | B | 101 |
| Tumwater | A | 183 |
| Wapato | C | 492 |
| Wapato-Galvin | C | 40 |
| Wilkeson | B | 31,465 |
| Winston | A | 45 |
| Water(Fresh) | - | 7,090 |
| Water(Salt) | - | 970 |
| Total | | 372,426 |

Table 4. Soil series and hydrologic groups by basin, Puget Sound Area (con)
(in acres) 1/

| Soil Series | Hydrologic Group | Acres |
|---|---|---|
| **DESCHUTES BASIN** | | |
| Alderwood | B | 11,836 |
| Bellingham | D | 1,628 |
| Camas | A | 347 |
| Cathcart | C | 1,102 |
| Chehalis | A | 1,680 |
| Delphi | B | 380 |
| Edmonds | D | 46 |
| Eld | A | 193 |
| Everett | A | 32,426 |
| Everson | C | 1,129 |
| Fitch | A | 4,210 |
| Giles | B | 13,095 |
| Greenwood(peat) | A | 83 |
| Grove | A | 40 |
| Indianola | A | 3,193 |
| Kapowsin | B | 820 |
| Kitsap | C | 13,411 |
| Lynden | A | 1,750 |
| Made Land | - | 350 |
| Maytown | B | 261 |
| McKenna | D | 653 |
| Melbourne | C | 1,608 |
| Mukilteo | A | 2,728 |
| Newberg | A | 625 |
| Nisqually | A | 9,781 |
| Norma | C | 564 |
| Olympic | C | 8,099 |
| Prather | B | 15 |
| Puget | B | 385 |
| Puyallup | B | 1,087 |
| Reed | D | 369 |
| Rifle(peat) | A | 856 |
| Riverwash | A | 122 |
| Rough Mountainous Land | B | 27,341 |
| Rough Mountainous Land | C | 335 |
| Semiahmoo | D | 950 |
| Shuwah | A | 72 |
| Snohomish | B | 3 |
| Spanaway | A | 12,395 |
| Sultan | B | 785 |
| Tacoma(muck) | B | 346 |
| Tenino | B | 1,694 |
| Tidal Marsh | B | 460 |
| Tisch | C | 394 |
| Tromp | B | 381 |
| Tromp-Tisch | B | 30 |
| Tumwater | A | 6,384 |
| Waddell | C | 66 |
| Wapato | C | 1,070 |
| Water(Fresh) | - | 2,582 |
| Water(Salt) | - | 16,348 |
| Total | | 186,508 |
| **WEST SOUND BASINS** | | |
| Active Dune | B | 156 |
| Agnew | A | 4,057 |
| Ahl | B | 944 |
| Ahl complex | B | 2,373 |
| Alderwood | B | 264,726 |
| Alderwood complex | B | 191 |
| Alluvial soils | A | 8,265 |
| Belfast | C | 331 |
| Belfast | D | 1,153 |
| Bellingham | D | 5,238 |
| Bow | D | 1,304 |
| Bozarth | C | 167 |
| Carbondale(muck) | D | 22 |
| Carlsborg | A | 81 |
| Carstairs | A | 3,060 |
| Casey | C | 15 |
| Casey | D | 456 |
| Cathcart | C | 1,678 |
| Chehalis | A | 157 |
| Chimacum | A | 7,081 |
| Clallam | C | 30,219 |
| Cloquallum | C | 13,792 |

| Soil Series | Hydrologic Group | Acres |
|---|---|---|
| Coastal Beach | A | 3,157 |
| Colvos | B | 4,927 |
| Colvos complex | B | 3,898 |
| Daybob | B | 6,918 |
| Delphi | B | 4,822 |
| Dick | A | 825 |
| Dick complex | A | 451 |
| Discovery Bay | C | 2,511 |
| Discovery Bay complex | A | 3,435 |
| Discovery Bay complex | C | 2,085 |
| Dungeness | B | 3,291 |
| Dupont | D | 29 |
| Ebeys | B | 167 |
| Edmonds | D | 5,771 |
| Eld | A | 571 |
| Elwha | C | 258 |
| Everett | A | 143,217 |
| Everson | C | 90 |
| Fitch | A | 82 |
| Galvin | C | 65 |
| Giles | B | 1,703 |
| Gravel Pit | A | 78 |
| Greenwood(peat) | A | 901 |
| Grove | A | 36,095 |
| Harstine | B | 7,583 |
| Hoodsport | A | 34,081 |
| Hoodsport | B | 9,377 |
| Hovde | B | 127 |
| Hoypus | A | 1,013 |
| Indianola | A | 39,862 |
| Jolley | B | 6,156 |
| Juno | A | 1,162 |
| Kapowsin | B | 2,703 |
| Keystone | A | 1,205 |
| Kitsap | C | 19,113 |
| Koch | D | 166 |
| Lummi | C | 378 |
| Lynden | A | 348 |
| Lystair | A | 1,929 |
| Made Land | - | 646 |
| Maytown | B | 2,243 |
| McKenna | D | 1,120 |
| McMurray(peat) | A | 2,918 |
| McMurray(muck) | D | 1,316 |
| Melbourne | C | 1,661 |
| Mukilteo | A | 6,003 |
| Newberg | A | 21 |
| Nisqually | A | 26 |
| Nordby | B | 700 |
| Norma | C | 3,282 |
| Nuby | C | 454 |
| Olete | C | 4,216 |
| Olete complex | C | 6,410 |
| Olympic | C | 223 |
| Orcas(peat) | A | 562 |
| Pilchuck | A | 952 |
| Puget | B | 581 |
| Puyallup | B | 18 |
| Quilcene | C | 3,282 |
| Ragnar | A | 3 |
| Reed | D | 624 |
| Rifle(peat) | A | 1,983 |
| Riverwash | A | 767 |
| Rough Broken Land | B | 6,048 |
| Rough Broken Land | C | 9,240 |
| Rough Mountainous Land | A | 7,746 |
| Rough Mountainous Land | B | 19,816 |
| Rough Mountainous Land | C | 38,863 |
| San Juan | A | 921 |
| Saxon | C | 308 |
| Semiahmoo | A | 854 |
| Semiahmoo | D | 2,221 |
| Sequim | A | 1,046 |
| Shelton | B | 30,732 |
| Sinclair | B | 39,641 |
| Skokomish | B | 924 |
| Snohomish | B | 220 |

| Soil Series | Hydrologic Group | Acres |
|---|---|---|
| Spalding(peat) | A | 49 |
| Spalding(peat) | D | 1,114 |
| Spanaway | A | 75 |
| Steep Broken Land | B | 5,717 |
| Sultan | B | 29 |
| Swantown | C | 1,593 |
| Tacoma(muck) | B | 55 |
| Tacoma(peat) | A | 509 |
| Tanwax | A | 465 |
| Tebo | C | 1,218 |
| Tidal Marsh | B | 2,674 |
| Tisch | C | 197 |
| Townsend | B | 452 |
| Waddell | C | 1,187 |
| Wapato | C | 840 |
| Whidbey | A | 4,734 |
| Unclassified | - | 3 |
| Water(Fresh) | - | 10,265 |
| Water(Salt) | - | 136,902 |
| Water(Salt)Undistrib.by W.S. | - | 263,897 |
| Total | | 1,326,582 |
| **ELWHA-DUNGENESS BASINS** | | |
| Agnew | A | 4,467 |
| Agnew-Elwha complex | C | 761 |
| Bellingham | D | 2,834 |
| Carlsborg | A | 2,585 |
| Chehalis | A | 113 |
| Clallam | C | 24,415 |
| Coastal Beach | A | 1,765 |
| Crescent | B | 947 |
| Dick | A | 2,903 |
| Dungeness | B | 6,297 |
| Elwha | C | 18,640 |
| Everett | A | 4,342 |
| Greenwood(peat) | A | 13 |
| Pilchuck | A | 1,685 |
| Puget | B | 1,204 |
| Rifle(peat) | A | 405 |
| Riverwash | A | 779 |
| Rough Broken Land | A | 7,067 |
| Rough Mountainous Land | A | 24,752 |
| Semiahmoo | A | 405 |
| Sequim | A | 1,438 |
| Spalding(peat) | A | 307 |
| Tidal Marsh | B | 110 |
| Townsend | B | 83 |
| Water(Fresh) | - | 965 |
| Water(Salt) | - | 198,467 |
| Total | | 307,749 |
| **SAN JUAN ISLANDS** | | |
| Active Dune | B | 116 |
| Alderwood | B | 3,338 |
| Bellingham | D | 1,971 |
| Bow | D | 13,274 |
| Coastal Beach | A | 1,013 |
| Coveland | C | 7,344 |
| Everett | A | 4,207 |
| Hovde | B | 79 |
| Indianola | A | 1,002 |
| Indianola-Roche | A | 1,264 |
| Neptune | A | 35 |
| Norma | C | 675 |
| Orcas(peat) | A | 55 |
| Pickett complex | C | 21,395 |
| Roche | D | 18,355 |
| Roche-Rock | D | 26,362 |
| Rock Land | D | 6,782 |
| San Juan | A | 1,554 |
| San Juan | B | 913 |
| Semiahmoo | A | 304 |
| Semiahmoo | D | 1,284 |
| Tanwax | A | 85 |
| Tidal Marsh | B | 166 |
| Water(Fresh) | - | 955 |
| Water(Salt) | - | 288,152 |
| Total | | 400,680 |

1/ Unadjusted measurements, 1966, for Puget Sound Area Study, based on National Cooperative Soil Survey maps.

Table 5. Soil series and hydrologic groups by watershed, Puget Sound Area.
(in acres) 1/

| Soil Series | Hydrologic Group | Acres |
|---|---|---|
| **NOOKSACK-SUMAS BASINS** | | |
| **NOOKSACK** | | |
| **North Fork Nooksack 10-1 2/** | | |
| Barneston | A | 9,469 |
| Barnhardt | A | 8 |
| Cagey | D | 756 |
| Cagey-Norma | D | 67 |
| Carbondale(muck) | D | 24 |
| Clipper | C | 390 |
| Fresh Water Marsh | A | 10 |
| Giles | B | 280 |
| Heisler | B | 178 |
| Kline | A | 289 |
| Mukilteo | A | 3 |
| Norma | C | 218 |
| Pilchuck | A | 1,451 |
| Puget | B | 11 |
| Puyallup | B | 623 |
| Rifle(peat) | A | 80 |
| Riverwash | A | 522 |
| Rough Mountainous Land | C | 49,748 |
| Rough Stony Land | C | 173 |
| Semiahmoo | D | 45 |
| Smith Creek | A | 280 |
| Squalicum | B | 186 |
| Squalicum-Alderwood | B | 855 |
| Wickersham | C | 110 |
| Water(Fresh) | - | 893 |
| Total | | 66,669 |
| **Middle Fork Nooksack 10-2 2/** | | |
| Barneston | A | 1,265 |
| Cagey | D | 34 |
| Clipper | C | 151 |
| Carbondale(muck) | D | 13 |
| Fresh Water Marsh | A | 5 |
| Greenwood(peat) | A | 24 |
| Kline | A | 191 |
| Lynden | A | 83 |
| Mukilteo | A | 24 |
| Norma | C | 11 |
| Pilchuck | A | 249 |
| Puyallup | B | 78 |
| Rifle(peat) | A | 14 |
| Riverwash | A | 175 |
| Rough Mountainous Land | C | 29,425 |
| Schnorbush | C | 97 |
| Semiahmoo | D | 19 |
| Smith Creek | A | 7 |
| Squalicum-Alderwood | B | 320 |
| Sumas | C | 3 |
| Water(Fresh) | - | 356 |
| Total | | 32,544 |
| **South Fork Nooksack 10-3 2/** | | |
| Barneston | A | 2,766 |
| Bellingham | D | 30 |
| Bow | D | 16 |
| Cagey | D | 116 |
| Carbondale(muck) | D | 169 |
| Clipper | C | 381 |
| Cokedale | C | 326 |
| Fresh Water Marsh | A | 8 |
| Giles | B | 56 |
| Heisler | B | 943 |
| Kline | A | 217 |
| LaBounty-McKenna | C | 131 |
| Lynden | A | 230 |
| Mukilteo | A | 66 |
| Nooksack | C | 652 |
| Norma | C | 62 |
| Pilchuck | A | 1,358 |
| Puget | B | 1,706 |
| Puyallup | B | 3,063 |
| Rifle(peat) | A | 219 |
| Riverwash | A | 479 |
| Rough Broken Land | C | 370 |
| Rough Mountainous Land | C | 78,245 |
| Rough Stony Land | C | 343 |
| Schnorbush | C | 1,297 |

| Soil Series | Hydrologic Group | Acres |
|---|---|---|
| **South Fork (Con.)** | | |
| Schnorbush-Norma | C | 276 |
| Semiahmoo | D | 12 |
| Skagit | B | 32 |
| Smith Creek | A | 259 |
| Squalicum-Alderwood | B | 1,196 |
| Sumas | C | 234 |
| Thornwood | A | 723 |
| Whatcom | D | 97 |
| Wickersham | C | 314 |
| Water(Fresh) | - | 951 |
| Total | | 97,343 |
| **Middle Tribs.Nooksack 10-4 2/** | | |
| Barneston | A | 18 |
| Bow | D | 13 |
| Cagey | D | 392 |
| Carbondale(muck) | D | 134 |
| Custer | D | 5 |
| Giles | B | 299 |
| Kickerville | B | 539 |
| Kline | A | 232 |
| LaBounty | C | 256 |
| LaBounty-McKenna | C | 470 |
| Lynden | A | 468 |
| McKenna | D | 327 |
| Mukilteo | A | 16 |
| Nooksack | C | 1,093 |
| Norma | C | 188 |
| Pilchuck | A | 1,239 |
| Puget | B | 78 |
| Puyallup | B | 3,761 |
| Rifle(peat) | A | 325 |
| Riverwash | A | 591 |
| Rough Mountainous Land | C | 10,757 |
| Saxon | B | 5 |
| Smith Creek | A | 16 |
| Snohomish | B | 154 |
| Squalicum | B | 370 |
| Sumas | C | 40 |
| Whatcom | D | 1,551 |
| Whatcom-McKenna | D | 394 |
| Water(Fresh) | - | 1,417 |
| Total | | 25,148 |
| **Anderson Creek 10-5 2/** | | |
| Bellingham | D | 181 |
| Bow | D | 173 |
| Cagey | D | 10 |
| Carbondale(muck) | D | 17 |
| Clipper | C | 57 |
| Giles | B | 269 |
| Hale-Norma | C | 472 |
| Indianola | A | 455 |
| LaBounty | C | 343 |
| LaBounty-McKenna | C | 940 |
| McKenna | D | 220 |
| Mukilteo | A | 8 |
| Norma | C | 138 |
| Puyallup | B | 170 |
| Rifle(peat) | A | 13 |
| Riverwash | A | 27 |
| Rough Mountainous Land | C | 2,244 |
| Salal | B | 40 |
| Saxon | B | 5 |
| Smith Creek | A | 207 |
| Squalicum | B | 987 |
| Tromp | B | 10 |
| Whatcom | D | 1,134 |
| Whatcom-McKenna | D | 669 |
| Total | | 8,789 |
| **Bertrand-Fishtrap 10-6 2/** | | |
| Cagey | D | 201 |
| Carbondale(muck) | D | 967 |
| Custer | D | 601 |
| Edmonds | D | 576 |
| Edmonds-Tromp | D | 853 |
| Everson | C | 1,232 |
| Giles | B | 2,504 |
| Giles-Tromp | B | 327 |

| Soil Series | Hydrologic Group | Acres |
|---|---|---|
| **Bertrand-Fishtrap (Con.)** | | |
| Hemmi | C | 132 |
| Indianola | A | 13 |
| Kickerville | B | 1,540 |
| LaBounty | C | 126 |
| LaBounty-McKenna | C | 317 |
| Lynden | A | 2,431 |
| McKenna | D | 336 |
| Mukilteo | A | 8 |
| Nooksack | C | 431 |
| Norma | C | 361 |
| Puget | B | 430 |
| Puyallup | B | 740 |
| Rifle(peat) | A | 3,059 |
| Riverwash | A | 6 |
| Salal | B | 187 |
| Semiahmoo | D | 15 |
| Snohomish | B | 184 |
| Sumas | C | 88 |
| Tromp | B | 1,374 |
| Tromp-Custer | B | 272 |
| Tromp-Edmonds | B | 232 |
| Whatcom | D | 1,932 |
| Whatcom-McKenna | D | 179 |
| Woodlyn | C | 2,260 |
| Water(Fresh) | - | 265 |
| Total | | 24,179 |
| **Wiser Lake-Ten Mile 10-7 2/** | | |
| Bellingham | D | 288 |
| Bow | D | 180 |
| Bow-Bellingham | D | 120 |
| Cagey | D | 595 |
| Cagey-Norma | D | 149 |
| Carbondale(muck) | D | 898 |
| Cathcart | C | 23 |
| Custer | D | 1,489 |
| Edmonds | D | 146 |
| Everson | C | 728 |
| Fresh Water Marsh | A | 6 |
| Giles | B | 2,448 |
| Hale-Norma | C | 48 |
| Hemmi | C | 79 |
| Indianola | A | 777 |
| Kickerville | B | 2,297 |
| LaBounty | C | 888 |
| LaBounty-McKenna | C | 1,430 |
| Lynden | A | 6,306 |
| McKenna | D | 651 |
| Melbourne | C | 11 |
| Nooksack | C | 1,111 |
| Norma | C | 74 |
| Pilchuck | A | 26 |
| Puget | B | 646 |
| Puyallup | B | 2,083 |
| Rifle(peat) | A | 4,316 |
| Riverwash | A | 39 |
| Saxon | B | 53 |
| Smith Creek | A | 29 |
| Snohomish | B | 454 |
| Squalicum-Alderwood | B | 108 |
| Sumas | C | 35 |
| Tromp | B | 992 |
| Tromp-Custer | B | 1,146 |
| Tromp-Edmonds | B | 17 |
| Tromp-Woodlyn | B | 35 |
| Whatcom | D | 5,563 |
| Whatcom-McKenna | D | 1,771 |
| Woodlyn | C | 250 |
| Water(Fresh) | - | 310 |
| Total | | 38,615 |
| **Lower Tribs.Nooksack 10-8 2/** | | |
| Bellingham | D | 112 |
| Bow | D | 212 |
| Cagey | D | 1,172 |
| Carbondale(muck) | D | 191 |
| Clipper | C | 17 |
| Coastal Beach | A | 2 |
| Custer | D | 764 |
| Edmonds | D | 338 |
| Everson | C | 31 |

Table 5. Soil series and hydrologic groups by watershed, Puget Sound Area (con.)

(in acres) [1]

| Soil Series | Hydrologic Group | Acres |
|---|---|---|
| NOOKSACK-SUMAS BASINS (Con.) | | |
| Lower Tribs. Nooksack (Con.) | | |
| Fresh Water Marsh | A | 11 |
| Giles | B | 86 |
| Giles-Tromp | B | 22 |
| Hale | C | 728 |
| Hovde | B | 114 |
| Indianola | A | 262 |
| Kickerville | B | 249 |
| LaBounty | C | 860 |
| LaBounty-McKenna | C | 172 |
| Lummi | C | 149 |
| Lynden | A | 1,974 |
| McKenna | D | 659 |
| Mukilteo | A | 45 |
| Neptune | A | 81 |
| Nooksack | C | 320 |
| Norma | C | 814 |
| Puget | B | 1,185 |
| Puyallup | B | 1,603 |
| Rifle(Bellingham complex) | A | 35 |
| Rifle(peat) | A | 758 |
| Sumas | C | 3,065 |
| Tidal Marsh | B | 322 |
| Tromp | B | 575 |
| Whatcom | D | 2,907 |
| Water(Fresh) | - | 1,024 |
| Water(Salt) | - | 1,619 |
| Total | | 22,478 |
| SUMAS | | |
| Upper South Tribs. 11-1[2] | | |
| Barneston | A | 83 |
| Cagey | D | 61 |
| Carbondale | D | 6 |
| Clipper | C | 24 |
| Heisler | B | 8 |
| Norma | C | 8 |
| Rough Mountainous Land | C | 4,856 |
| Squalicum-Alderwood | B | 77 |
| Total | | 5,123 |
| Saar Creek 11-2[2] | | |
| Barneston | A | 388 |
| Bellingham | D | 59 |
| Cagey | D | 26 |
| Carbondale | D | 171 |
| Clipper | C | 130 |
| Indianola | A | 6 |
| LaBounty | C | 80 |
| LaBounty-McKenna | C | 72 |
| McKenna | D | 32 |
| Norma | C | 68 |
| Rifle | A | 58 |
| Puget | B | 217 |
| Puyallup | B | 2,200 |
| Rough Mountainous Land | C | 3,993 |
| Samish | D | 260 |
| Squalicum | B | 875 |
| Squalicum-Alderwood | B | 421 |
| Sumas | C | 554 |
| Total | | 9,610 |
| Sumas River 11-3[2] | | |
| Barneston | A | 1,937 |
| Bellingham | D | 10 |
| Bow | D | 377 |
| Cagey | D | 287 |
| Cagey-Norma | D | 21 |
| Carbondale | D | 763 |
| Clipper | C | 441 |
| Giles | B | 266 |
| Indianola | A | 206 |
| Kickerville | B | 2,191 |
| Kline | A | 616 |
| LaBounty | C | 75 |
| LaBounty-McKenna | C | 338 |
| McKenna | D | 249 |
| Mukilteo | A | 10 |
| Sumas River (Con.) | | |
| Nooksack | C | 1,894 |
| Norma | C | 53 |
| Pilchuck | A | 44 |
| Puget | B | 1,495 |
| Puyallup | B | 6,756 |
| Rifle | A | 1,639 |
| Rough Mountainous Land | C | 7,183 |
| Samish | D | 45 |
| Saxon | B | 20 |
| Semiahmoo | D | 16 |
| Skagit | B | 262 |
| Smith Creek | A | 322 |
| Snohomish | B | 40 |
| Squalicum | B | 2,104 |
| Squalicum-Alderwood | B | 271 |
| Sumas | C | 1,317 |
| Whatcom | D | 1,413 |
| Whatcom-McKenna | D | 229 |
| Wickersham | C | 189 |
| Water(Fresh) | - | 137 |
| Total | | 33,216 |
| PACIFIC DRAINAGES | | |
| Dakota Creek 0-1[2] | | |
| Barnhardt | A | 1,732 |
| Bellingham | D | 851 |
| Bow | D | 337 |
| Bow-Bellingham | D | 262 |
| Cagey | D | 860 |
| Carbondale(muck) | D | 127 |
| Custer | D | 3,259 |
| Edmonds | D | 47 |
| Everson | C | 107 |
| Giles | B | 1,708 |
| Giles-Tromp | B | 66 |
| Hemmi | C | 250 |
| Indianola | A | 48 |
| Kickerville | B | 254 |
| LaBounty | C | 499 |
| LaBounty-McKenna | C | 467 |
| Lynden | A | 1,312 |
| McKenna | D | 219 |
| Mukilteo | A | 8 |
| Norma | C | 351 |
| Puyallup | B | 175 |
| Rifle(peat) | A | 108 |
| Saxon | B | 356 |
| Semiahmoo | D | 26 |
| Squalicum-Alderwood | B | 693 |
| Tromp | B | 1,456 |
| Tromp-Custer | B | 421 |
| Whatcom | D | 3,267 |
| Whatcom-McKenna | D | 1,048 |
| Water(Fresh) | - | 52 |
| Water(Salt) | - | 998 |
| Total | | 21,364 |
| Coastal Creeks 0-2[2] | | |
| Barneston | A | 25 |
| Barnhardt | A | 1,208 |
| Bellingham | D | 221 |
| Bow | D | 284 |
| Cagey | D | 3,789 |
| Cagey-Norma | D | 106 |
| Carbondale(muck) | D | 4 |
| Coastal Beach | A | 401 |
| Fresh Water Marsh | A | 3 |
| Hale | C | 445 |
| Hale-Norma | C | 65 |
| Hovde | B | 106 |
| Indianola | A | 25 |
| Kickerville | B | 2,267 |
| LaBounty | C | 961 |
| LaBounty-McKenna | C | 364 |
| Lummi | C | 151 |
| Lynden | A | 5 |
| McKenna | D | 905 |
| Mukilteo | A | 259 |
| Neptune | A | 577 |
| Norma | C | 2,524 |
| Coastal Creeks (Con.) | | |
| Norma-Cagey | C | 837 |
| Norma-Hale | C | 388 |
| Rifle(peat) | A | 258 |
| Saxon | B | 73 |
| Semiahmoo | D | 46 |
| Smith Creek | A | 55 |
| Sumas | C | 42 |
| Tidal Marsh | B | 15 |
| Whatcom | D | 293 |
| Water(Fresh) | - | 3 |
| Water(Salt) | - | 11,950 |
| Total | | 28,555 |
| Terrell Creek 0-3[2] | | |
| Bellingham | D | 576 |
| Bow | D | 147 |
| Cagey | D | 1,643 |
| Cagey-Norma | D | 51 |
| Clipper | C | 55 |
| Hale | C | 1,005 |
| Hale-Norma | C | 49 |
| Kickerville | B | 516 |
| LaBounty | C | 1,001 |
| Lynden | A | 6 |
| McKenna | D | 900 |
| Mukilteo | A | 214 |
| Neptune | A | 96 |
| Norma | C | 1,687 |
| Norma-Cagey | C | 146 |
| Saxon | B | 128 |
| Semiahmoo | D | 27 |
| Sumas | C | 36 |
| Whatcom | D | 1,220 |
| Water(Fresh) | - | 438 |
| Water(Salt) | - | 657 |
| Total | | 10,598 |
| California Creek 0-4[2] | | |
| Belfast | D | 370 |
| Bellingham | D | 872 |
| Bow | D | 1,748 |
| Bow-Bellingham | D | 345 |
| Cagey | D | 103 |
| Carbondale(muck) | D | 125 |
| Custer | D | 2,144 |
| Edmonds | D | 92 |
| Everson | C | 10 |
| Giles | B | 271 |
| Giles-Tromp | B | 101 |
| Hale | C | 378 |
| Hemmi | C | 29 |
| Indianola | A | 32 |
| LaBounty | C | 862 |
| LaBounty-McKenna | C | 151 |
| Lynden | A | 1,991 |
| McKenna | D | 309 |
| Nooksack | C | 7 |
| Norma | C | 229 |
| Rifle(peat) | A | 751 |
| Saxon | B | 3 |
| Semiahmoo | D | 15 |
| Sumas | C | 37 |
| Tromp | B | 398 |
| Whatcom | D | 2,794 |
| Whatcom-McKenna | D | 25 |
| Water(Fresh) | - | 69 |
| Water(Salt) | - | 48 |
| Total | | 14,309 |
| Silver Creek 0-5[2] | | |
| Bellingham | D | 413 |
| Bow | D | 84 |
| Cagey | D | 73 |
| Carbondale(muck) | D | 60 |
| Edmonds | D | 71 |
| Everson | C | 160 |
| Fresh Water Marsh | A | 4 |
| Giles | B | 973 |
| Hale | C | 17 |
| Hemmi | C | 66 |

Table 5. Soil series and hydrologic groups by watershed, Puget Sound Area (con.)

(in acres) 1/

| Soil Series | Hydrologic Group | Acres |
|---|---|---|
| **PACIFIC DRAINAGES (Con.)** | | |
| **Silver Creek (Con.)** 0-5 2/ | | |
| Hovde | B | 9 |
| Kickerville | B | 48 |
| LaBounty | C | 835 |
| LaBounty-McKenna | C | 711 |
| Lummi | C | 153 |
| Lynden | A | 380 |
| McKenna | D | 471 |
| Neptune | A | 68 |
| Norma | C | 139 |
| Puget | B | 94 |
| Puyallup | B | 493 |
| Rifle(peat) | A | 141 |
| Saxon | B | 14 |
| Semiahmoo | D | 20 |
| Sumas | C | 236 |
| Tidal Marsh | B | 37 |
| Tromp | B | 110 |
| Tromp-Custer | B | 6 |
| Whatcom | D | 3,063 |
| Whatcom-McKenna | D | 1,905 |
| Woodlyn | C | 12 |
| Water(Fresh) | - | 139 |
| Water(Salt) | - | 360 |
| Total | | 11,555 |
| **Squalicum Creek** 0-6 2/ | | |
| Barnhardt | A | 30 |
| Bellingham | D | 828 |
| Bow | D | 367 |
| Bow-Bellingham | D | 126 |
| Cagey | D | 34 |
| Cagey-Norma | D | 50 |
| Clipper | C | 155 |
| Kickerville | B | 110 |
| LaBounty | C | 1,022 |
| LaBounty-McKenna | C | 1,496 |
| Made Land | - | 47 |
| McKenna | D | 932 |
| Norma | C | 8 |
| Rifle(peat) | A | 129 |
| Rough Mountainous Land | C | 1,069 |
| Rough Stony Land | C | 22 |
| Saxon | B | 65 |
| Smith Creek | A | 840 |
| Squalicum | B | 807 |
| Tromp | B | 8 |
| Whatcom | D | 6,932 |
| Whatcom-McKenna | D | 2,159 |
| Water(Fresh) | - | 48 |
| Water(Salt) | - | 86 |
| Total | | 17,370 |
| **Lake Whatcom** 0-7 2/ | | |
| Barneston | A | 1,118 |
| Bellingham | D | 162 |
| Bow | D | 292 |
| Cagey | D | 574 |
| Cagey-Norma | D | 69 |
| Carbondale(muck) | D | 98 |
| Cathcart | C | 902 |
| Clipper | C | 164 |
| Fresh Water Marsh | A | 12 |
| Heisler | B | 47 |
| Kickerville | B | 10 |
| Kline | A | 143 |
| LaBounty | C | 691 |
| LaBounty-McKenna | C | 1,262 |
| Made Land | - | 87 |
| McKenna | D | 551 |
| Mukilteo | A | 2 |
| Norma | C | 185 |
| Puget | B | 3 |
| Puyallup | B | 22 |
| Rifle(peat) | A | 117 |
| Rough Mountainous Land | C | 21,372 |
| Rough Stony Land | C | 39 |
| Saxon | B | 11 |
| Schnorbush | C | 13 |
| Skagit | B | 68 |
| Squalicum | B | 7,601 |
| **Lake Whatcom (Con.)** | | |
| Squalicum-Alderwood | B | 787 |
| Whatcom | D | 211 |
| Whatcom-McKenna | D | 42 |
| Wickersham | C | 180 |
| Water(Fresh) | - | 5,198 |
| Water(Salt) | - | 488 |
| Total | | 42,521 |
| **Chuckanut Mountain** 0-8 2/ | | |
| Alderwood | B | 530 |
| Barneston | A | 308 |
| Barnhardt | A | 114 |
| Bellingham | D | 8 |
| Bow | D | 705 |
| Cagey | D | 26 |
| Carbondale(muck) | D | 73 |
| Cathcart | C | 1,675 |
| Clipper | C | 53 |
| Everett | A | 110 |
| Kickerville | B | 19 |
| Klaus | A | 3 |
| Kline | A | 46 |
| LaBounty | C | 383 |
| LaBounty-McKenna | C | 87 |
| Lummi | C | 27 |
| Lynden | A | 14 |
| Made Land | - | 114 |
| McKenna | D | 421 |
| Mukilteo | A | 39 |
| Norma | C | 44 |
| Puget | B | 148 |
| Puyallup | B | 8 |
| Rifle(peat) | A | 32 |
| Rough Broken Land | C | 668 |
| Rough Mountainous Land | C | 10,730 |
| Rough Stony Land | C | 216 |
| Samish | D | 11 |
| Squalicum | B | 2,403 |
| Squalicum-Alderwood | B | 2,779 |
| Steep Broken Land | B | 11 |
| Sumas | C | 17 |
| Tanwax | A | 39 |
| Tidal Marsh | B | 26 |
| Whatcom | D | 331 |
| Whatcom-McKenna | D | 134 |
| Water(Fresh) | - | 177 |
| Water(Salt) | - | 5,401 |
| Total | | 27,930 |
| **Lummi Island** 0-9 2/ | | |
| Barnhardt | A | 269 |
| Bellingham | D | 8 |
| Bow | D | 65 |
| Cagey | D | 3,008 |
| Cagey-Norma | D | 3 |
| Coastal Beach | A | 40 |
| Fresh Water Marsh | A | 80 |
| Hale | C | 93 |
| Hovde | B | 11 |
| Indianola | A | 28 |
| Kickerville | B | 2,825 |
| LaBounty | C | 273 |
| LaBounty-McKenna | C | 718 |
| McKenna | D | 657 |
| Mukilteo | A | 14 |
| Neptune | A | 169 |
| Norma | C | 255 |
| Rough Mountainous Land | C | 2,997 |
| Rough Stony Land | C | 157 |
| Saxon | B | 8 |
| Semiahmoo | D | 29 |
| Whatcom | D | 37 |
| Water(Salt) | - | 15,517 |
| Total | | 27,261 |
| **SKAGIT-SAMISH BASINS** | | |
| **SKAGIT** | | |
| **Upper Skagit** 9-1 2/ | | |
| Bellingham | D | 40 |
| Bow | D | 140 |
| **Upper Skagit (Con.)** | | |
| Carbondale(muck) | D | 8 |
| Cathcart | C | 363 |
| Cokedale | C | 435 |
| Corkindale | B | 752 |
| Everett | A | 68 |
| Giles | B | 178 |
| Gilligan | B | 45 |
| Klaus | A | 2,387 |
| Kline | A | 1,087 |
| Lynden | A | 186 |
| Pilchuck | A | 980 |
| Puget | B | 142 |
| Puyallup | B | 3,431 |
| Riverwash | A | 448 |
| Rough Broken Land | C | 1,142 |
| Rough Mountainous Land | C | 15,585 |
| Sauk | B | 508 |
| Skykomish | A | 320 |
| Squalicum | B | 65 |
| Sultan | B | 50 |
| Sumas | C | 13 |
| Wickersham | C | 275 |
| Woodinville | B | 85 |
| Water(Fresh) | - | 1,107 |
| Total | | 29,840 |
| **Baker River** 9-2 2/ | | |
| Alderwood | B | 1,137 |
| Corkindale | B | 40 |
| Everett | A | 123 |
| Klaus | A | 1,349 |
| Kline | A | 54 |
| Made Land | - | 7 |
| Mukilteo | A | 83 |
| Norma | C | 103 |
| Oso | B | 1,485 |
| Rifle(peat) | A | 26 |
| Rough Broken Land | C | 5,413 |
| Rough Mountainous Land | C | 12,123 |
| Semiahmoo | D | 18 |
| Snohomish | B | 12 |
| Squalicum | B | 405 |
| Tanwax | A | 49 |
| Water(Fresh) | - | 2,073 |
| Total | | 24,500 |
| **Cascade River** 9-3 2/ | | |
| Indianola | A | 65 |
| Kline | A | 145 |
| Marblemount | C | 60 |
| Pilchuck | A | 210 |
| Puyallup | B | 186 |
| Riverwash | A | 115 |
| Rough Broken Land | C | 10 |
| Rough Mountainous Land | C | 16,352 |
| Sauk | B | 10 |
| Skykomish | A | 540 |
| Water(Fresh) | - | 196 |
| Total | | 17,889 |
| **Suiattle River** 9-4 2/ | | |
| Cathcart | C | 95 |
| Corkindale | B | 25 |
| Giles | B | 25 |
| Greenwater | A | 1,730 |
| Klaus | A | 315 |
| Kline | A | 80 |
| Pilchuck | A | 1,110 |
| Puyallup | B | 115 |
| Riverwash | A | 105 |
| Rough Broken Land | C | 905 |
| Rough Mountainous Land | C | 8,737 |
| Samish | D | 55 |
| Skykomish | A | 905 |
| Tanwax | A | 5 |
| Wickersham | C | 45 |
| Water(Fresh) | - | 485 |
| Total | | 14,737 |

Table 5. Soil series and hydrologic groups by watershed, Puget Sound Area (con.)

(in acres) 1/

| Soil Series | Hydrologic Group | Acres |
|---|---|---|
| **SKAGIT-SAMISH (Con.)** | | |
| **Sauk River** 9-5 2/ | | |
| Bellingham | D | 15 |
| Carbondale(muck) | D | 35 |
| Cathcart | C | 400 |
| Cokedale | C | 90 |
| Custer | D | 70 |
| Edmonds | D | 25 |
| Everett | A | 422 |
| Giles | B | 90 |
| Greenwater | A | 2,005 |
| Greenwood(peat) | A | 60 |
| Heisler | B | 20 |
| Indianola | A | 270 |
| Kitsap | C | 30 |
| Klaus | A | 2,870 |
| Kline | A | 55 |
| Lynden | A | 1,835 |
| Norma | C | 5 |
| Pilchuck | A | 2,695 |
| Puget | B | 145 |
| Puyallup | B | 2,515 |
| Riverwash | A | 958 |
| Rough Broken Land | C | 2,084 |
| Rough Mountainous Land | C | 14,843 |
| Rough Stony Land | C | 10 |
| Samish | D | 195 |
| Sauk | B | 20 |
| Skykomish | A | 2,017 |
| Tanwax | A | 35 |
| Thornwood | A | 200 |
| Wickersham | C | 625 |
| Water(Fresh) | - | 1,151 |
| Total | - | 35,790 |
| **North Skagit Tribs.** 9-6 2/ | | |
| Alderwood | B | 103 |
| Belfast | D | 199 |
| Bellingham | D | 85 |
| Bow | D | 1,011 |
| Cathcart | C | 262 |
| Cokedale | C | 232 |
| Cokedale-Puyallup | C | 524 |
| Corkindale | B | 110 |
| Everett | A | 1,149 |
| Giles | B | 636 |
| Gilligan | B | 986 |
| Greenwood(peat) | A | 44 |
| Heisler | B | 652 |
| Indianola | A | 140 |
| Kline | A | 232 |
| Lynden | A | 2,407 |
| Made Land | - | 20 |
| Mukilteo | A | 31 |
| Norma | C | 74 |
| Oso | B | 75 |
| Pilchuck | A | 577 |
| Puget | B | 205 |
| Puyallup | B | 7,979 |
| Rifle(peat) | A | 42 |
| Riverwash | A | 351 |
| Rough Broken Land | C | 3,018 |
| Rough Mountainous Land | C | 29,147 |
| Samish | D | 421 |
| Saxon | B | 10 |
| Saxon | C | 89 |
| Semiahmoo | D | 9 |
| Skiyou | B | 3,944 |
| Snohomish | B | 2 |
| Squalicum | B | 533 |
| Sultan | B | 303 |
| Sumas | C | 766 |
| Tanwax | A | 6 |
| Thornton | D | 65 |
| Thornwood | A | 9,748 |
| Wickersham | C | 964 |
| Water(Fresh) | - | 1,031 |
| Total | | 68,182 |

| Soil Series | Hydrologic Group | Acres |
|---|---|---|
| **South Skagit Tribs.** 9-7 2/ | | |
| Alderwood | B | 30 |
| Bellingham | D | 30 |
| Cathcart | C | 252 |
| Cokedale | C | 758 |
| Cokedale-Puyallup | C | 10 |
| Everett | A | 991 |
| Giles | B | 831 |
| Gilligan | B | 954 |
| Heisler | B | 357 |
| Indianola | A | 187 |
| Klaus | A | 338 |
| Kline | A | 84 |
| Lynden | A | 861 |
| Norma | C | 62 |
| Pilchuck | A | 1,102 |
| Puget | B | 12 |
| Puyallup | B | 3,120 |
| Rifle(peat) | A | 25 |
| Riverwash | A | 1,119 |
| Rough Broken Land | C | 5,745 |
| Rough Mountainous Land | C | 53,780 |
| Samish | D | 126 |
| Skiyou | B | 739 |
| Sultan | B | 211 |
| Sumas | C | 13 |
| Thornton | D | 1,309 |
| Thornwood | A | 2,324 |
| Wickersham | C | 634 |
| Water(Fresh) | - | 2,363 |
| Total | | 78,367 |
| **Gages Slough** 9-8 2/ | | |
| Alderwood | B | 190 |
| Bow | D | 1,408 |
| Cokedale | C | 58 |
| Cokedale-Puyallup | C | 27 |
| Everett | A | 136 |
| Giles | B | 18 |
| Heisler | B | 7 |
| Made Land | - | 5 |
| Mukilteo | A | 3 |
| Norma | C | 2 |
| Pilchuck | A | 369 |
| Puget | B | 925 |
| Puyallup | B | 9,311 |
| Puyallup-Puget | B | 29 |
| Riverwash | A | 104 |
| Rough Broken Land | C | 40 |
| Rough Mountainous Land | C | 202 |
| Samish | D | 7 |
| Saxon | C | 4 |
| Semiahmoo | D | 18 |
| Snohomish | B | 13 |
| Squalicum | B | 235 |
| Sultan | B | 303 |
| Sumas | C | 1,003 |
| Unclassified | - | 2 |
| Water(Fresh) | - | 335 |
| Total | | 14,754 |
| **Nookachamps** 9-9 2/ | | |
| Alderwood | B | 6,284 |
| Belfast | D | 133 |
| Bellingham | D | 1,057 |
| Bow | D | 4,411 |
| Carbondale(muck) | D | 31 |
| Cathcart | C | 5,081 |
| Everett | A | 511 |
| Giles | B | 11 |
| Greenwood(peat) | A | 30 |
| Heisler | B | 283 |
| Indianola | A | 6 |
| Kline | A | 165 |
| Lynden | A | 5 |
| Mukilteo | A | 45 |
| Nookachamps | D | 1,420 |
| Norma | C | 123 |
| Oso | B | 480 |
| Pilchuck | A | 95 |
| Puget | B | 399 |
| Puyallup | B | 1,790 |

| Soil Series | Hydrologic Group | Acres |
|---|---|---|
| **Nookachamps (Con.)** | | |
| Rifle(peat) | A | 456 |
| Riverwash | A | 68 |
| Rough Broken Land | C | 736 |
| Rough Mountainous Land | C | 15,540 |
| Saxon | B | 50 |
| Skiyou | B | 2,478 |
| Snohomish | B | 60 |
| Squalicum | B | 3,371 |
| Sultan | B | 1,016 |
| Sumas | C | 574 |
| Tanwax | A | 40 |
| Thornwood | A | 441 |
| Tisch | C | 222 |
| Wickersham | C | 165 |
| Water(Fresh) | - | 1,461 |
| Total | | 49,038 |
| **South Mt. Vernon** 9-10 2/ | | |
| Alderwood | B | 6,733 |
| Bellingham | D | 960 |
| Bow | D | 2,883 |
| Carbondale(muck) | D | 395 |
| Cathcart | C | 3,245 |
| Edmonds | D | 55 |
| Everett | A | 1,992 |
| Greenwood(peat) | A | 15 |
| Indianola | A | 130 |
| Kitsap | C | 332 |
| Kline | A | 25 |
| Mukilteo | A | 75 |
| Norma | C | 520 |
| Oso | B | 65 |
| Pilchuck | A | 94 |
| Puget | B | 3,343 |
| Puyallup | B | 2,558 |
| Rifle(peat) | A | 353 |
| Riverwash | A | 31 |
| Rough Broken Land | C | 380 |
| Rough Mountainous Land | C | 3,843 |
| Semiahmoo | D | 20 |
| Skykomish | A | 345 |
| Snohomish | B | 60 |
| Squalicum | B | 253 |
| Sultan | B | 314 |
| Sumas | C | 2,747 |
| Tanwax | A | 11 |
| Tidal Marsh | B | 355 |
| Water(Fresh) | - | 485 |
| Water(Salt) | - | 830 |
| Total | | 33,447 |
| **SAMISH** | | |
| **Samish River** 9-14 2/ | | |
| Alderwood | B | 3,017 |
| Barneston | A | 1,890 |
| Barnhardt | A | 8 |
| Belfast | D | 448 |
| Bellingham | D | 793 |
| Bow | D | 10,698 |
| Cagey | D | 378 |
| Cagey-Norma | D | 24 |
| Carbondale(muck) | D | 236 |
| Cathcart | C | 93 |
| Clipper | C | 30 |
| Coastal Beach | A | 75 |
| Cokedale | C | 365 |
| Cokedale-Puyallup | C | 3 |
| Coveland | C | 112 |
| Everett | A | 2,935 |
| Giles | B | 315 |
| Gilligan | B | 107 |
| Greenwood(peat) | A | 2 |
| Heisler | B | 412 |
| Hovde | B | 33 |
| Indianola | A | 106 |
| Kickerville | B | 70 |
| Kline | A | 430 |
| LaBounty | C | 57 |
| LaBounty-McKenna | C | 18 |
| Lummi | C | 314 |

Table 5. Soil series and hydrologic groups by watershed, Puget Sound Area (con.)
(in acres) 1/

| Soil Series | Hydrologic Group | Acres |
|---|---|---|
| **SKAGIT-SAMISH (Con.)** | | |
| **Samish River (Con.)** | | |
| Lynden | A | 596 |
| Made Land | - | 48 |
| McKenna | D | 93 |
| Mukilteo | A | 94 |
| Neptune | A | 5 |
| Nookachamps | D | 56 |
| Nooksack | C | 70 |
| Norma | C | 126 |
| Oso | B | 11 |
| Pilchuck | A | 117 |
| Puget | B | 8,048 |
| Puyallup | B | 7,779 |
| Rifle(peat) | A | 774 |
| Riverwash | A | 25 |
| Rough Broken Land | C | 2,662 |
| Rough Mountainous Land | C | 27,472 |
| Rough Stony Land | C | 17 |
| Samish | D | 1,573 |
| Saxon | B | 372 |
| Semiahmoo | D | 844 |
| Skagit | B | 164 |
| Skykomish | A | 17 |
| Snohomish | B | 969 |
| Squalicum | B | 2,865 |
| Squalicum-Alderwood | B | 2,217 |
| Sultan | B | 312 |
| Sumas | C | 3,706 |
| Tanwax | A | 31 |
| Thornwood | D | 1,787 |
| Tidal Marsh | B | 367 |
| Wickersham | C | 1,220 |
| Woodinville | B | 276 |
| Water(Fresh) | - | 983 |
| Water(Salt) | - | 5,234 |
| Total | | 93,899 |
| **PACIFIC DRAINAGES** | | |
| **Fidalgo Island Group** 0-10 2/ | | |
| Alderwood | B | 9,177 |
| Bellingham | D | 520 |
| Bow | D | 5,821 |
| Cagey | D | 518 |
| Cathcart | C | 20 |
| Coastal Beach | A | 429 |
| Coveland | C | 1,203 |
| Everett | A | 1,734 |
| Fidalgo | C | 5,198 |
| Giles | B | 190 |
| Hovde | B | 6 |
| Indianola | A | 701 |
| Kline | A | 50 |
| Lummi | C | 861 |
| Lynden | A | 151 |
| Made Land | - | 237 |
| Mukilteo | A | 138 |
| Norma | C | 361 |
| Pilchuck | A | 15 |
| Rifle(peat) | A | 7 |
| Rough Broken Land | C | 682 |
| Rough Mountainous Land | C | 9,006 |
| Samish | D | 170 |
| Semiahmoo | D | 181 |
| Squalicum | B | 1,041 |
| Sumas | C | 355 |
| Tanwax | A | 47 |
| Tidal Marsh | B | 450 |
| Tisch | C | 20 |
| Water(Fresh) | - | 1,010 |
| Water(Salt) | - | 32,162 |
| Total | | 72,461 |
| **Skagit Flats** 0-15 2/ | | |
| Alderwood | B | 163 |
| Bellingham | D | 280 |
| Bow | D | 6,120 |
| Cagey | D | 130 |
| Cathcart | C | 245 |
| Everett | A | 113 |
| **Skagit Flats (Con.)** | | |
| Indianola | A | 45 |
| Lummi | C | 1,290 |
| Made Land | - | 400 |
| Mukilteo | A | 10 |
| Neptune | A | 5 |
| Norma | C | 31 |
| Pilchuck | A | 149 |
| Puget | B | 14,774 |
| Puyallup | B | 6,640 |
| Puyallup-Puget | B | 196 |
| Riverwash | A | 49 |
| Rough Broken Land | C | 73 |
| Rough Mountainous Land | C | 299 |
| Semiahmoo | D | 55 |
| Sultan | B | 214 |
| Sumas | C | 7,261 |
| Tidal Marsh | B | 2,598 |
| Water(Fresh) | - | 1,777 |
| Water(Salt) | - | 4,918 |
| Total | | 47,835 |
| **STILLAGUAMISH BASIN** | | |
| **PACIFIC DRAINAGES** | | |
| **N. Fork Stillag. R.** 0-17 2/ | | |
| Alderwood | B | 1,562 |
| Bellingham | D | 125 |
| Carbondale(muck) | D | 402 |
| Cathcart | C | 30 |
| Custer | D | 70 |
| Edmonds | D | 335 |
| Everett | A | 6,203 |
| Greenwood(peat) | A | 21 |
| Indianola | A | 2,519 |
| Kitsap | C | 110 |
| Klaus | A | 305 |
| Kline | A | 60 |
| Lynden | A | 4,733 |
| Mukilteo | A | 309 |
| Norma | C | 435 |
| Oso | B | 1,617 |
| Pilchuck | A | 280 |
| Puget | B | 4,447 |
| Puyallup | B | 2,236 |
| Rifle(peat) | A | 110 |
| Riverwash | A | 668 |
| Rough Broken Land | C | 12,957 |
| Rough Mountainous Land | C | 41,844 |
| Rough Stony Land | C | 1,010 |
| Skykomish | A | 5,790 |
| Snohomish | B | 20 |
| Sultan | B | 215 |
| Tidal Marsh | B | 10 |
| Water(Fresh) | - | 1,287 |
| Total | | 89,710 |
| **S. Fork Stillag. R.** 0-18 2/ | | |
| Alderwood | B | 3,920 |
| Bellingham | D | 63 |
| Carbondale(muck) | D | 425 |
| Cathcart | C | 35 |
| Edmonds | D | 195 |
| Everett | A | 2,002 |
| Greenwood(peat) | A | 245 |
| Indianola | A | 931 |
| Kitsap | C | 140 |
| Lynden | A | 2,316 |
| Mukilteo | A | 426 |
| Norma | C | 269 |
| Oso | B | 2,755 |
| Pilchuck | A | 20 |
| Puget | B | 385 |
| Puyallup | B | 776 |
| Rifle(peat) | A | 330 |
| Riverwash | A | 460 |
| Rough Broken Land | C | 3,895 |
| Rough Mountainous Land | C | 18,682 |
| Rough Stony Land | C | 3,119 |
| Skykomish | A | 6,496 |
| Snohomish | B | 45 |
| **S. Fork Stillag. R. (Con.)** | | |
| Sultan | B | 269 |
| Water(Fresh) | - | 569 |
| Total | | 48,768 |
| **Jim Creek** 0-19 2/ | | |
| Alderwood | B | 1,375 |
| Bellingham | D | 65 |
| Carbondale(muck) | D | 75 |
| Edmonds | D | 64 |
| Everett | A | 1,390 |
| Greenwood(peat) | A | 30 |
| Indianola | A | 986 |
| Kitsap | C | 446 |
| Lynden | A | 803 |
| Mukilteo | A | 54 |
| Norma | C | 185 |
| Oso | B | 865 |
| Puget | B | 80 |
| Puyallup | B | 390 |
| Rifle(peat) | A | 15 |
| Riverwash | A | 95 |
| Rough Broken Land | C | 3,584 |
| Rough Mountainous Land | C | 14,063 |
| Rough Stony Land | C | 1,045 |
| Skykomish | A | 1,185 |
| Sultan | B | 25 |
| Water(Fresh) | - | 146 |
| Total | | 26,966 |
| **Pilchuck Creek** 0-20 2/ | | |
| Alderwood | B | 8,456 |
| Belfast | D | 70 |
| Bellingham | D | 205 |
| Bow | D | 35 |
| Carbondale(muck) | D | 215 |
| Cathcart | C | 3,145 |
| Edmonds | D | 20 |
| Everett | A | 1,959 |
| Greenwood(peat) | A | 10 |
| Indianola | A | 788 |
| Kitsap | C | 545 |
| Klaus | A | 1,130 |
| Lynden | A | 290 |
| Made Land | - | 10 |
| Mukilteo | A | 480 |
| Norma | C | 445 |
| Oso | B | 5,028 |
| Puget | B | 548 |
| Puyallup | B | 190 |
| Rifle(peat | A | 558 |
| Riverwash | A | 10 |
| Rough Broken Land | C | 3,058 |
| Rough Mountainous Land | C | 19,356 |
| Saxon | B | 735 |
| Saxon | C | 220 |
| Skykomish | A | 768 |
| Squalicum | B | 525 |
| Tanwax | A | 10 |
| Water(Fresh) | - | 856 |
| Total | | 49,665 |
| **Lower Stillaguamish** 0-21 2/ | | |
| Alderwood | B | 10,248 |
| Bellingham | D | 135 |
| Carbondale(muck) | D | 810 |
| Cathcart | C | 50 |
| Custer | D | 45 |
| Edmonds | D | 250 |
| Everett | A | 2,682 |
| Greenwood(peat) | A | 35 |
| Indianola | A | 1,110 |
| Kitsap | C | 1,675 |
| Lynden | A | 1,798 |
| Mukilteo | A | 490 |
| Norma | C | 920 |
| Oso | B | 15 |
| Pilchuck | A | 10 |
| Puget | B | 8,915 |
| Puyallup | B | 1,554 |
| Rifle(peat) | A | 367 |

Table 5. Soil series and hydrologic groups by watershed, Puget Sound Area (con.)

(in acres) 1/

| Soil Series | Hydrologic Group | Acres |
|---|---|---|
| **STILLAGUAMISH BASIN (Con.)** | | |
| Lower Stillaguamish (Con.) | | |
| Riverwash | A | 315 |
| Rough Broken Land | C | 2,119 |
| Rough Mountainous Land | C | 330 |
| Rough Stony Land | C | 45 |
| Skykomish | A | 3,284 |
| Snohomish | B | 446 |
| Sultan | B | 110 |
| Tidal Marsh | B | 256 |
| Water(Fresh) | - | 1,568 |
| Water(Salt) | - | 1,822 |
| Total | | 41,404 |
| Church Creek 0-22 2/ | | |
| Alderwood | B | 2,572 |
| Bellingham | D | 372 |
| Carbondale(muck) | D | 215 |
| Edmonds | D | 45 |
| Everett | A | 290 |
| Indianola | A | 5 |
| Kitsap | C | 1,590 |
| Lynden | A | 10 |
| Norma | C | 130 |
| Pilchuck | A | 5 |
| Puget | B | 1,730 |
| Puyallup | B | 90 |
| Rough Broken Land | C | 265 |
| Skykomish | A | 97 |
| Snohomish | B | 150 |
| Tidal Marsh | B | 494 |
| Water(Fresh) | - | 9 |
| Water(Salt) | - | 361 |
| Total | | 8,430 |
| **SNOHOMISH BASIN** | | |
| Snoqualmie River 8a 2/ | | |
| Alderwood | B | 43,874 |
| Alluvial Soils | A | 911 |
| Barneston | A | 9,402 |
| Bellingham | D | 225 |
| Carbondale(muck) | D | 190 |
| Cathcart | C | 320 |
| Edgewick | A | 4,158 |
| Edmonds | D | 10 |
| Everett | A | 5,212 |
| Greenwater | A | 1,125 |
| Greenwood(peat) | A | 664 |
| Indianola | A | 941 |
| Issaquah | B | 93 |
| Kitsap | C | 2,791 |
| Klaus | A | 15,045 |
| Lynden | A | 395 |
| Marsh | B | 175 |
| Mukilteo | A | 599 |
| Nooksack | C | 3,166 |
| Norma | C | 403 |
| Oso | B | 3,700 |
| Pilchuck | A | 1,616 |
| Puget | B | 4,815 |
| Puyallup | B | 5,556 |
| Puyallup-Buckley | B | 35 |
| Ragnar | A | 2,029 |
| Rifle(Bellingham complex) | A | 550 |
| Rifle(peat) | A | 2,440 |
| Riverwash | A | 860 |
| Rough Broken Land | C | 13,429 |
| Rough Mountainous Land | C | 130,158 |
| Rough Stony Land | C | 3,919 |
| Salal | B | 533 |
| Sammamish | B | 135 |
| Snohomish | B | 1,234 |
| Snoqualmie | A | 4,733 |
| Stossell | C | 2,093 |
| Sultan | B | 821 |
| Tokul | A | 4,626 |
| Woodinville | B | 256 |
| Water(Fresh) | - | 6,237 |
| Total | | 279,474 |

| Soil Series | Hydrologic Group | Acres |
|---|---|---|
| Skykomish River 8b-1 2/ | | |
| Alderwood | B | 2,174 |
| Bellingham | D | 50 |
| Carbondale(muck) | D | 84 |
| Custer | D | 35 |
| Edmonds | D | 75 |
| Everett | A | 4,886 |
| Greenwood(peat) | A | 15 |
| Indianola | A | 212 |
| Kitsap | C | 3,941 |
| Lynden | A | 2,857 |
| Mukilteo | A | 403 |
| Norma | C | 307 |
| Oso | B | 607 |
| Pilchuck | A | 2,460 |
| Puget | B | 1,026 |
| Puyallup | B | 2,071 |
| Rifle(peat) | A | 72 |
| Riverwash | A | 1,041 |
| Rough Broken Land | C | 6,649 |
| Rough Mountainous Land | C | 37,783 |
| Rough Stony Land | C | 10,812 |
| Skykomish | A | 5,382 |
| Snohomish | B | 25 |
| Sultan | B | 2,816 |
| Water(Fresh) | - | 2,495 |
| Total | | 88,278 |
| Sultan River 8b-2 2/ | | |
| Alderwood | B | 888 |
| Custer | D | 5 |
| Everett | A | 6,615 |
| Greenwood(peat) | A | 28 |
| Indianola | A | 183 |
| Kitsap | C | 390 |
| Lynden | A | 194 |
| Mukilteo | A | 180 |
| Norma | C | 40 |
| Oso | B | 18 |
| Puyallup | B | 180 |
| Rifle(peat) | A | 260 |
| Rough Broken Land | C | 33,594 |
| Rough Mountainous Land | C | 725 |
| Skykomish | A | 1,962 |
| Sultan | B | 502 |
| Water(Fresh) | - | 447 |
| Total | | 46,211 |
| Woods Creek 8b-4 2/ | | |
| Alderwood | B | 11,192 |
| Bellingham | D | 180 |
| Carbondale(muck) | D | 115 |
| Cathcart | C | 328 |
| Custer | D | 135 |
| Edmonds | D | 277 |
| Everett | A | 12,720 |
| Greenwood(peat) | A | 73 |
| Indianola | A | 363 |
| Kitsap | C | 2,703 |
| Lynden | A | 180 |
| Mukilteo | A | 396 |
| Norma | C | 1,018 |
| Oso | B | 60 |
| Puget | B | 20 |
| Rifle(peat) | A | 253 |
| Rough Broken Land | C | 4,212 |
| Rough Mountainous Land | C | 2,459 |
| Rough Stony Land | C | 295 |
| Skykomish | A | 2,123 |
| Sultan | B | 961 |
| Water(Fresh) | - | 494 |
| Total | | 40,557 |
| Pilchuck River 8-1 2/ | | |
| Alderwood | B | 26,280 |
| Bellingham | D | 298 |
| Carbondale(muck) | D | 404 |
| Cathcart | C | 230 |
| Edmonds | D | 227 |
| Everett | A | 13,803 |

| Soil Series | Hydrologic Group | Acres |
|---|---|---|
| Pilchuck River (Con.) | | |
| Greenwood(peat) | A | 160 |
| Indianola | A | 175 |
| Kitsap | C | 535 |
| Lynden | A | 2,577 |
| Mukilteo | A | 813 |
| Norma | C | 1,749 |
| Oso | B | 598 |
| Pilchuck | A | 35 |
| Puget | B | 932 |
| Puyallup | B | 1,062 |
| Rifle(peat) | A | 883 |
| Riverwash | A | 250 |
| Rough Broken Land | C | 2,741 |
| Rough Mountainous Land | C | 14,959 |
| Rough Stony Land | C | 1,770 |
| Skykomish | A | 2,179 |
| Sultan | B | 383 |
| Water(Fresh) | - | 1,830 |
| Total | | 74,873 |
| French Creek 8-2 2/ | | |
| Alderwood | B | 3,393 |
| Bellingham | D | 334 |
| Carbondale(muck) | D | 143 |
| Cathcart | C | 60 |
| Edmonds | D | 172 |
| Everett | A | 4,537 |
| Greenwood(peat) | A | 8 |
| Indianola | A | 20 |
| Kitsap | C | 669 |
| Lynden | A | 854 |
| Mukilteo | A | 1,946 |
| Norma | C | 201 |
| Pilchuck | A | 25 |
| Puget | B | 1,618 |
| Puyallup | B | 376 |
| Rifle(peat) | A | 194 |
| Riverwash | A | 35 |
| Rough Broken Land | C | 1,078 |
| Rough Mountainous Land | C | 7 |
| Rough Stony Land | C | 297 |
| Snohomish | B | 1,018 |
| Sultan | B | 890 |
| Water(Fresh) | - | 190 |
| Total | | 18,065 |
| Cathcart Area 8-3 2/ | | |
| Alderwood | B | 3,249 |
| Bellingham | D | 155 |
| Carbondale(muck) | D | 45 |
| Cathcart | C | 310 |
| Edmonds | D | 55 |
| Everett | A | 2,029 |
| Greenwood(peat) | A | 5 |
| Kitsap | C | 195 |
| Lynden | A | 20 |
| Mukilteo | A | 90 |
| Norma | C | 293 |
| Pilchuck | A | 65 |
| Puget | B | 766 |
| Puyallup | B | 280 |
| Rifle(peat) | A | 20 |
| Riverwash | A | 105 |
| Rough Broken Land | C | 212 |
| Rough Stony Land | C | 988 |
| Skykomish | A | 15 |
| Water(Fresh) | - | 349 |
| Total | | 9,246 |
| Snohomish Estuary 8-4 2/ | | |
| Alderwood | B | 16,713 |
| Bellingham | D | 540 |
| Carbondale(muck) | D | 1,208 |
| Cathcart | C | 50 |
| Coastal Beach | A | 10 |
| Custer | D | 4,692 |
| Edmonds | D | 259 |
| Everett | A | 2,006 |
| Greenwood(peat) | A | 110 |

Table 5. Soil series and hydrologic groups by watershed, Puget Sound Area (con.)

(*in acres*) 1/

| Soil Series | Hydrologic Group | Acres |
|---|---|---|
| **SNOHOMISH BASIN (Con.)** | | |
| **Snohomish Estuary (Con.)** | | |
| Indianola | A | 212 |
| Kitsap | C | 861 |
| Lynden | A | 7,278 |
| Made Land | - | 290 |
| Mukilteo | A | 1,473 |
| Norma | C | 3,821 |
| Pilchuck | A | 65 |
| Puget | B | 5,111 |
| Puyallup | B | 685 |
| Rifle(peat) | A | 435 |
| Rough Broken Land | C | 858 |
| Skykomish | A | 20 |
| Snohomish | B | 2,942 |
| Tidal Marsh | B | 583 |
| Water(Fresh) | - | 1,997 |
| Water(Salt) | - | 798 |
| Total | | 53,017 |
| **Marshland Area** 8-5 2/ | | |
| Alderwood | B | 5,545 |
| Carbondale(muck) | D | 68 |
| Cathcart | C | 449 |
| Edmonds | D | 15 |
| Everett | A | 1,648 |
| Greenwood(peat) | A | 23 |
| Indianola | A | 158 |
| Lynden | A | 20 |
| Mukilteo | A | 650 |
| Norma | C | 212 |
| Pilchuck | A | 70 |
| Puget | B | 1,670 |
| Puyallup | B | 898 |
| Rifle(peat) | A | 170 |
| Riverwash | A | 20 |
| Rough Broken Land | C | 557 |
| Snohomish | B | 2,491 |
| Sultan | B | 299 |
| Water(Fresh) | - | 304 |
| Total | | 15,267 |
| **PACIFIC DRAINAGES** | | |
| **Edmond-Mukilteo** 0-26 2/ | | |
| Alderwood | B | 14,444 |
| Bellingham | D | 76 |
| Carbondale(muck) | D | 162 |
| Coastal Beach | A | 209 |
| Custer | D | 65 |
| Edmonds | D | 90 |
| Everett | A | 4,225 |
| Greenwood(peat) | A | 44 |
| Indianola | A | 253 |
| Kitsap | C | 30 |
| Lynden | A | 145 |
| Made Land | - | 15 |
| Mukilteo | A | 126 |
| Norma | C | 359 |
| Puyallup | B | 40 |
| Rifle(peat) | A | 101 |
| Rough Broken Land | C | 4,002 |
| Tidal Marsh | B | 100 |
| Water(Fresh) | - | 47 |
| Water(Salt) | - | 9,268 |
| Total | | 33,801 |
| **Tulalip-Warm Beach** 0-33 2/ | | |
| Alderwood | B | 19,156 |
| Bellingham | D | 470 |
| Carbondale(muck) | D | 70 |
| Coastal Beach | A | 70 |
| Edmonds | D | 327 |
| Everett | A | 3,871 |
| Greenwood(peat) | A | 178 |
| Indianola | A | 237 |
| Kitsap | C | 350 |
| Mukilteo | A | 130 |
| Norma | C | 210 |
| **Tulalip-Warm Beach (Con.)** | | |
| Puget | B | 202 |
| Rifle(peat) | A | 601 |
| Rough Broken Land | C | 565 |
| Water(Fresh) | - | 1,098 |
| Water(Salt) | - | 6,485 |
| Total | | 34,020 |
| **CEDAR BASIN** | | |
| **PACIFIC DRAINAGES** | | |
| **Swamp,Bear,North Cr.** 0-27 2/ | | |
| Alderwood | B | 29,184 |
| Bellingham | D | 155 |
| Carbondale(muck) | D | 1,208 |
| Edmonds | D | 407 |
| Everett | A | 8,242 |
| Greenwood(peat) | A | 91 |
| Indianola | A | 437 |
| Kitsap | C | 247 |
| Lynden | A | 142 |
| Marsh | B | 15 |
| Mukilteo | A | 304 |
| Norma | C | 2,524 |
| Puget | B | 211 |
| Puyallup | B | 182 |
| Rifle(peat) | A | 1,009 |
| Rough Broken Land | C | 200 |
| Snohomish | B | 207 |
| Sultan | B | 30 |
| Water(Fresh) | - | 281 |
| Total | | 45,076 |
| **Lake Washington** 0-28 2/ | | |
| Alderwood | B | 38,629 |
| Alluvial Soils | A | 86 |
| Barneston | A | 254 |
| Bellingham | D | 820 |
| Carbondale(muck) | D | 294 |
| Cathcart | C | 907 |
| Coastal Beach | A | 30 |
| Edgewick | A | 33 |
| Edmonds | D | 15 |
| Everett | A | 5,730 |
| Greenwood(peat) | A | 47 |
| Indianola | A | 5,755 |
| Kitsap | C | 5,392 |
| Lynden | A | 647 |
| Made Land | - | 121 |
| Marsh | B | 47 |
| Mukilteo | A | 340 |
| Norma | C | 1,185 |
| Pilchuck | A | 206 |
| Puget | B | 158 |
| Puyallup | B | 793 |
| Rifle(peat) | A | 1,063 |
| Riverwash | A | 40 |
| Rough Broken Land | C | 791 |
| Rough Mountainous Land | C | 5,393 |
| Snohomish | B | 62 |
| Snoqualmie | A | 7 |
| Unclassified | - | 13,651 |
| Water(Fresh) | - | 22,690 |
| Total | | 105,186 |
| **Upper West Slope Seattle** 0-29a 2/ | | |
| Alderwood | B | 3,132 |
| Bellingham | D | 13 |
| Carbondale(muck) | D | 2 |
| Coastal Beach | A | 47 |
| Everett | A | 1,317 |
| Indianola | A | 60 |
| Kitsap | C | 999 |
| Made Land | - | 1 |
| Norma | C | 81 |
| Rifle(peat) | A | 60 |
| Rough Broken Land | C | 56 |
| Unclassified | - | 14,624 |
| **Upper West Slope Seattle (Con.)** | | |
| Water(Fresh) | - | 1,019 |
| Water(Salt) | - | 18,686 |
| Total | | 40,097 |
| **Sammamish River** 0-30 2/ | | |
| Alderwood | B | 43,157 |
| Alluvial Soils | A | 492 |
| Barneston | A | 6,504 |
| Bellingham | D | 677 |
| Buckley | D | 12 |
| Carbondale(muck) | D | 222 |
| Cathcart | C | 1,243 |
| Coastal Beach | A | 57 |
| Everett | A | 6,660 |
| Greenwood(peat) | A | 209 |
| Indianola | A | 1,542 |
| Issaquah | B | 312 |
| Kitsap | C | 4,748 |
| Lynden | A | 1,406 |
| Made Land | - | 11 |
| Marsh | B | 7 |
| Mukilteo | A | 447 |
| Norma | C | 996 |
| Pilchuck | A | 190 |
| Puget | B | 2,519 |
| Puyallup | B | 1,910 |
| Rifle(peat) | A | 1,865 |
| Riverwash | A | 31 |
| Rough Broken Land | C | 4,332 |
| Rough Mountainous Land | C | 19,649 |
| Salal | B | 15 |
| Sammamish | B | 550 |
| Snohomish | B | 130 |
| Snoqualmie | A | 1,169 |
| Sultan | B | 236 |
| Woodinville | B | 211 |
| Water(Fresh) | - | 5,632 |
| Total | | 107,141 |
| **Cedar River** 0-31 2/ | | |
| Alderwood | B | 17,507 |
| Alluvial Soils | A | 86 |
| Barneston | A | 14,416 |
| Bellingham | D | 101 |
| Carbondale(muck) | D | 77 |
| Cathcart | C | 558 |
| Everett | A | 862 |
| Greenwood(peat) | A | 147 |
| Indianola | A | 272 |
| Kitsap | C | 532 |
| Klaus | A | 414 |
| Lynden | A | 55 |
| Made Land | - | 45 |
| Marsh | B | 15 |
| Mukilteo | A | 71 |
| Norma | C | 258 |
| Pilchuck | A | 867 |
| Puget | B | 141 |
| Puyallup | B | 1,153 |
| Rifle(peat) | A | 664 |
| Riverwash | A | 276 |
| Rough Broken Land | C | 3,487 |
| Rough Mountainous Land | C | 6,450 |
| Snohomish | B | 12 |
| Snoqualmie | A | 729 |
| Sultan | B | 85 |
| Water(Fresh) | - | 938 |
| Total | | 50,218 |
| **GREEN BASIN** | | |
| **PACIFIC DRAINAGES** | | |
| **Lower West Slope Seattle** 0-29b 2/ | | |
| Alderwood | B | 6,421 |
| Carbondale(muck) | D | 25 |
| Coastal Beach | A | 43 |

Table 5. Soil series and hydrologic groups by watershed, Puget Sound Area (con.)

(in acres) 1/

| Soil Series | Hydrologic Group | Acres |
|---|---|---|
| **GREEN BASIN (Con.)** | | |
| **Lower West Slope Seattle (Con.)** | | |
| Everett | A | 1,116 |
| Greenwood(peat) | A | 64 |
| Indianola | A | 710 |
| Kitsap | C | 354 |
| Klaus | A | 10 |
| Lynden | A | 28 |
| Mukilteo | A | 11 |
| Norma | C | 127 |
| Puget | B | 40 |
| Rifle(peat) | A | 38 |
| Rough Broken Land | C | 1,065 |
| Unclassified | - | 6,812 |
| Water(Fresh) | - | 63 |
| Water(Salt) | - | 17,410 |
| Total | | 34,337 |
| **East Side Green R. 0-34 2/** | | |
| Alderwood | B | 33,731 |
| Alluvial Soils | A | 97 |
| Barneston | A | 8,560 |
| Bellingham | D | 289 |
| Carbondale(muck) | D | 319 |
| Cathcart | C | 1,719 |
| Coastal Beach | A | 12 |
| Everett | A | 8,597 |
| Greenwood(peat) | A | 137 |
| Indianola | A | 331 |
| Kitsap | C | 48 |
| Lynden | A | 70 |
| Made Land | - | 77 |
| Marsh | B | 59 |
| Mukilteo | A | 141 |
| Norma | C | 851 |
| Pilchuck | A | 485 |
| Puget | B | 1,489 |
| Puyallup | B | 6,747 |
| Rifle(peat) | A | 1,165 |
| Riverwash | A | 167 |
| Rough Broken Land | C | 3,380 |
| Snohomish | B | 329 |
| Snoqualmie | A | 30 |
| Sultan | B | 1,723 |
| Woodinville | B | 155 |
| Unclassified | - | 4,301 |
| Water(Fresh) | - | 2,274 |
| Total | | 77,283 |
| **West Side Green R. 0-35 2/** | | |
| Alderwood | B | 11,186 |
| Alluvial Soils | A | 44 |
| Bellingham | D | 34 |
| Buckley | D | 578 |
| Carbondale(muck) | D | 641 |
| Cathcart | C | 671 |
| Coastal Beach | A | 15 |
| Enumclaw | B | 395 |
| Everett | A | 770 |
| Greenwood(peat) | A | 172 |
| Indianola | A | 351 |
| Kitsap | C | 27 |
| Lynden | A | 38 |
| Made Land | - | 25 |
| Marsh | B | 7 |
| Mukilteo | A | 115 |
| Norma | C | 85 |
| Pilchuck | A | 575 |
| Puget | B | 1,764 |
| Puyallup | B | 6,366 |
| Rifle(peat) | A | 177 |
| Riverwash | A | 95 |
| Rough Broken Land | C | 2,960 |
| Sammamish | B | 70 |
| Snohomish | B | 426 |
| Sultan | B | 1,390 |
| Woodinville | B | 339 |
| Unclassified | - | 2,136 |
| Water(Fresh) | - | 952 |
| Total | | 32,404 |
| **Lakota-Des Moines 0-36 2/** | | |
| Alderwood | B | 13,027 |
| Bellingham | D | 66 |
| Carbondale(muck) | D | 34 |
| Coastal Beach | A | 17 |
| Everett | A | 898 |
| Indianola | A | 665 |
| Kitsap | C | 285 |
| Lynden | A | 99 |
| Mukilteo | A | 98 |
| Norma | C | 123 |
| Rifle(peat) | A | 54 |
| Rough Broken Land | C | 1,184 |
| Water(Fresh) | - | 41 |
| Water(Salt) | - | 12,523 |
| Total | | 29,114 |
| **Upper Green River 0-37 2/** | | |
| Alderwood | B | 6,692 |
| Alluvial Soils | A | 89 |
| Barneston | A | 10,850 |
| Bellingham | D | 58 |
| Buckley | D | 3,554 |
| Carbondale(muck) | D | 260 |
| Cathcart | C | 4,182 |
| Enumclaw | B | 1,566 |
| Everett | A | 20 |
| Greenwood(peat) | A | 5 |
| Indianola | A | 462 |
| Kitsap | C | 15 |
| Klaus | A | 932 |
| Lynden | A | 85 |
| Made Land | - | 186 |
| Mukilteo | A | 43 |
| Norma | C | 254 |
| Pilchuck | A | 97 |
| Puget | B | 37 |
| Puyallup | B | 1,066 |
| Puyallup-Buckley | B | 9 |
| Rifle(peat) | A | 777 |
| Riverwash | A | 133 |
| Rough Broken Land | C | 2,822 |
| Rough Mountainous Land | C | 47,118 |
| Sammamish | B | 22 |
| Snoqualmie | A | 137 |
| Sultan | B | 602 |
| Water(Fresh) | - | 2,210 |
| Total | | 84,283 |
| **PUYALLUP BASIN** | | |
| **White River 7-1 2/** | | |
| Alderwood | B | 13,776 |
| Alluvial Soils | A | 219 |
| Barneston | A | 2,033 |
| Bellingham | D | 26 |
| Bow | D | 20 |
| Buckley | D | 10,098 |
| Buckley-Enumclaw | D | 934 |
| Carbondale(muck) | D | 730 |
| Cathcart | C | 115 |
| Edgewick | A | 430 |
| Edmonds | D | 8 |
| Enumclaw | B | 5,304 |
| Everett | A | 3,367 |
| Greenwater | A | 3,713 |
| Greenwood(peat) | A | 108 |
| Indianola | A | 229 |
| Kapowsin | B | 285 |
| Kitsap | C | 33 |
| Klaus | A | 503 |
| Lynden | A | 21 |
| Made Land | - | 68 |
| McKenna | D | 18 |
| Marsh | B | 12 |
| Mukilteo | A | 118 |
| Norma | C | 180 |
| Orting | C | 25 |
| Oso | B | 1,330 |
| Pilchuck | A | 3,276 |
| Puget | B | 221 |
| **White River (Con.)** | | |
| Puyallup | B | 3,829 |
| Puyallup-Buckley | B | 107 |
| Ragnar | A | 224 |
| Rifle(Bellingham complex) | A | 20 |
| Rifle(peat) | A | 565 |
| Riverwash | A | 2,520 |
| Rough Broken Land | C | 4,690 |
| Rough Mountainous Land | C | 60,652 |
| Semiahmoo | D | 536 |
| Skykomish | A | 12 |
| Snohomish | B | 617 |
| Snoqualmie | A | 267 |
| Spanaway | A | 10 |
| Stossell | C | 1,062 |
| Sultan | B | 913 |
| Tacoma(muck) | B | 20 |
| Tanwax | A | 40 |
| Tisch | C | 3 |
| Wilkeson | B | 90 |
| Woodinville | B | 65 |
| Water(Fresh) | - | 4,945 |
| Total | | 128,387 |
| **Carbon River 7-2 2/** | | |
| Alderwood | B | 105 |
| Barneston | A | 8,719 |
| Barneston-Wilkeson | A | 928 |
| Bellingham | D | 2 |
| Everett | A | 27 |
| Indianola | A | 729 |
| Made Land | - | 33 |
| McKenna | D | 10 |
| Mukilteo | A | 30 |
| Newberg | A | 15 |
| Norma | C | 73 |
| Orting | C | 1,208 |
| Pilchuck | A | 805 |
| Puget | B | 42 |
| Puyallup | B | 431 |
| Riverwash | A | 574 |
| Rough Broken Land | C | 14,407 |
| Rough Mountainous Land | C | 5,477 |
| Rough Stony Land | C | 2,757 |
| Semiahmoo | D | 72 |
| Skykomish | A | 65 |
| Sultan | B | 15 |
| Wilkeson | B | 5,[illegible]81 |
| Water(Fresh) | - | 4[illegible]4 |
| Total | | 42,939 |
| **Puyallup River 7-3 2/** | | |
| Alderwood | B | 6,639 |
| Barneston | A | 7,294 |
| Barneston-Wilkeson | A | 922 |
| Bellingham | D | 245 |
| Bow | D | 42 |
| Buckley | D | 234 |
| Buckley-Enumclaw | D | 22 |
| Carbondale(muck) | D | 167 |
| Cathcart | C | 5 |
| Chehalis | A | 15 |
| Dupont | D | 177 |
| Edmonds | D | 143 |
| Enumclaw | B | 1,414 |
| Everett | A | 16,043 |
| Greenwood(peat) | A | 12 |
| Indianola | A | 3,126 |
| Kapowsin | B | 8,116 |
| Kitsap | C | 1,097 |
| Kopiah | D | 58 |
| Lynden | A | 18 |
| Made Land | - | 150 |
| McKenna | D | 222 |
| Mukilteo | A | 24 |
| Newberg | A | 50 |
| Nisqually | A | 2 |
| Norma | C | 164 |
| Orting | C | 1,514 |
| Pilchuck | A | 2,323 |
| Puget | B | 53 |

Table 5. Soil series and hydrologic groups by watershed, Puget Sound Area (con.)
(in acres) 1/

| Soil Series | Hydrologic Group | Acres |
|---|---|---|
| **PUYALLUP BASIN (Con.)** | | |
| **Puyallup River (Con.)** | | |
| Puyallup | B | 8,790 |
| Rifle(peat) | A | 236 |
| Riverwash | A | 964 |
| Rough Broken Land | C | 19,851 |
| Rough Mountainous Land | C | 18,119 |
| Rough Stony Land | C | 4,540 |
| Semiahmoo | D | 452 |
| Sinclair | B | 45 |
| Skykomish | A | 138 |
| Snohomish | B | 67 |
| Spanaway | A | 5 |
| Sultan | B | 2,172 |
| Tacoma(muck) | B | 388 |
| Tanwax | A | 114 |
| Tidal Marsh | B | 20 |
| Tisch | C | 37 |
| Wapato | C | 3 |
| Wilkeson | B | 10,620 |
| Water(Fresh) | - | 1,731 |
| Water(Salt) | - | 70 |
| Total | | 118,653 |
| **South Prairie Creek** 7-4 2/ | | |
| Alderwood | B | 1,051 |
| Barneston | A | 5,558 |
| Barneston-Wilkeson | A | 165 |
| Bellingham | D | 198 |
| Buckley | D | 1,185 |
| Buckley-Enumclaw | D | 385 |
| Carbondale(muck) | D | 13 |
| Cathcart | C | 75 |
| Chehalis | A | 95 |
| Edmonds | D | 10 |
| Enumclaw | B | 670 |
| Everett | A | 1,226 |
| Greenwood(peat) | A | 6 |
| Indianola | A | 665 |
| Kapowsin | B | 287 |
| Kitsap | C | 100 |
| Lynden | A | 5 |
| Made Land | - | 175 |
| McKenna | D | 35 |
| Mukilteo | A | 8 |
| Newberg | A | 623 |
| Norma | C | 46 |
| Orting | C | 92 |
| Pilchuck | A | 80 |
| Puyallup | B | 14 |
| Rifle(peat) | A | 77 |
| Riverwash | A | 4 |
| Rough Broken Land | C | 10,346 |
| Rough Mountainous Land | C | 9,995 |
| Rough Stony Land | C | 1,513 |
| Semiahmoo | D | 30 |
| Spanaway | A | 5 |
| Sultan | B | 2 |
| Tanwax | A | 25 |
| Wapato | C | 3 |
| Wilkeson | B | 4,121 |
| Water(Fresh) | - | 66 |
| Total | | 38,954 |
| **PACIFIC DRAINAGES** | | |
| **Hylebos Creek** 0-38 2/ | | |
| Alderwood | B | 9,159 |
| Barneston | A | 10 |
| Bellingham | D | 42 |
| Bow | D | 132 |
| Carbondale(muck) | D | 64 |
| Coastal Beach | A | 5 |
| Dupont | D | 1 |
| Edmonds | D | 1 |
| Everett | A | 1,162 |
| Greenwood(peat) | A | 17 |
| Indianola | A | 239 |
| Kapowsin | B | 334 |
| Kitsap | C | 587 |
| **Hylebos Creek (Con.)** | | |
| Made Land | - | 240 |
| Marsh | B | 14 |
| Mukilteo | A | 69 |
| National | A | 1 |
| Norma | C | 123 |
| Pilchuck | A | 47 |
| Puget | B | 127 |
| Puyallup | B | 328 |
| Rifle(peat) | A | 105 |
| Rough Broken Land | C | 1,508 |
| Semiahmoo | D | 178 |
| Snohomish | B | 1 |
| Sultan | B | 901 |
| Tacoma(muck) | B | 545 |
| Tidal Marsh | B | 20 |
| Tisch | C | 20 |
| Water(Fresh) | - | 263 |
| Water(Salt) | - | 2,804 |
| Total | | 19,067 |
| **Wapato Creek** 0-39 2/ | | |
| Alderwood | B | 1,163 |
| Bellingham | D | 1 |
| Carbondale(muck) | D | 14 |
| Everett | A | 169 |
| Kapowsin | B | 530 |
| Made Land | - | 348 |
| McKenna | D | 11 |
| Mukilteo | A | 10 |
| Norma | C | 22 |
| Pilchuck | A | 85 |
| Puget | B | 30 |
| Puyallup | B | 1,254 |
| Rough Broken Land | C | 516 |
| Semiahmoo | D | 5 |
| Sinclair | B | 10 |
| Sultan | B | 1,158 |
| Tacoma(muck) | B | 748 |
| Tidal Marsh | B | 332 |
| Tisch | C | 1 |
| Water(Fresh) | - | 100 |
| Water(Salt) | - | 1,697 |
| Total | | 8,204 |
| **Clover Creek** 0-40 2/ | | |
| Alderwood | B | 12,689 |
| Bellingham | D | 311 |
| Bow | D | 215 |
| Coastal Beach | A | 109 |
| Dupont | D | 606 |
| Edmonds | D | 23 |
| Enumclaw | B | 35 |
| Everett | A | 16,422 |
| Fitch | A | 5,604 |
| Greenwood(peat) | A | 134 |
| Indianola | A | 215 |
| Kapowsin | B | 5,414 |
| Kitsap | C | 797 |
| Made Land | - | 997 |
| McKenna | D | 565 |
| Mukilteo | A | 349 |
| Nisqually | A | 587 |
| Norma | C | 91 |
| Pilchuck | A | 71 |
| Puget | B | 19 |
| Puyallup | B | 10 |
| Rifle(peat) | A | 128 |
| Rough Broken Land | C | 4,288 |
| Rough Mountainous Land | C | 588 |
| Semiahmoo | D | 748 |
| Sinclair | B | 8,628 |
| Snohomish | B | 27 |
| Spanaway | A | 46,593 |
| Sultan | B | 3,543 |
| Tanwax | A | 150 |
| Tisch | C | 159 |
| Water(Fresh) | - | 2,538 |
| Water(Salt) | - | 14,532 |
| Total | | 127,185 |
| **NISQUALLY BASIN** | | |
| **Muck Creek** 0-41 2/ | | |
| Alderwood | B | 296 |
| Bellingham | D | 653 |
| Bow | D | 8 |
| Carbondale(muck) | D | 38 |
| Dupont | D | 282 |
| Edmonds | D | 39 |
| Enumclaw | B | 1 |
| Everett | A | 15,519 |
| Fitch | A | 2,600 |
| Indianola | A | 664 |
| Kapowsin | B | 16,716 |
| Kitsap | C | 172 |
| Lynden | A | 178 |
| McKenna | D | 1,546 |
| Mukilteo | A | 78 |
| National | A | 40 |
| Nisqually | A | 1,385 |
| Norma | C | 792 |
| Orting | C | 258 |
| Pilchuck | A | 34 |
| Puyallup | B | 3 |
| Rifle(peat) | A | 190 |
| Rough Broken Land | C | 525 |
| Semiahmoo | D | 1,455 |
| Sinclair | B | 3,152 |
| Skykomish | A | 42 |
| Spanaway | A | 22,733 |
| Sultan | B | 630 |
| Tanwax | A | 117 |
| Thornwood | A | 50 |
| Tisch | C | 336 |
| Water(Fresh) | - | 344 |
| Total | | 70,876 |
| **Horn-Tanwax Creeks** 0-42 2/ | | |
| Bellingham | D | 376 |
| Bow | D | 18 |
| Dupont | D | 313 |
| Enumclaw | B | 25 |
| Everett | A | 8,571 |
| Greenwood(peat) | A | 23 |
| Indianola | A | 416 |
| Kapowsin | B | 16,409 |
| Kitsap | C | 30 |
| McKenna | D | 883 |
| Mukilteo | A | 239 |
| National | A | 2 |
| Norma | C | 277 |
| Orting | C | 176 |
| Pilchuck | A | 873 |
| Puget | B | 25 |
| Puyallup | B | 20 |
| Rifle(peat) | A | 140 |
| Riverwash | A | 60 |
| Rough Broken Land | C | 2,401 |
| Rough Mountainous Land | C | 5 |
| Rough Stony Land | C | 140 |
| Semiahmoo | D | 667 |
| Sinclair | B | 1,040 |
| Skykomish | A | 139 |
| Snohomish | B | 10 |
| Spanaway | A | 80 |
| Sultan | B | 15 |
| Tanwax | A | 151 |
| Tisch | C | 282 |
| Water(Fresh) | - | 819 |
| Total | | 34,625 |
| **Ohop Creek** 0-43 2/ | | |
| Barneston | A | 983 |
| Bellingham | D | 36 |
| Carbondale(muck) | D | 8 |
| Chehalis | A | 240 |
| Dupont | D | 183 |
| Everett | A | 1,807 |
| Indianola | A | 5 |
| Kapowsin | B | 3,420 |
| Kopiah | D | 37 |

Table 5. Soil series and hydrologic groups by watershed, Puget Sound Area (con.)

(in acres) 1/

| Soil Series | Hydrologic Group | Acres |
|---|---|---|
| **NISQUALLY BASIN (Con.)** | | |
| **Ohop Creek (Con.)** | | |
| McKenna | D | 5 |
| Mukilteo | A | 15 |
| Newberg | A | 232 |
| Norma | C | 15 |
| Orting | C | 20 |
| Pilchuck | A | 10 |
| Puyallup | B | 5 |
| Riverwash | A | 4 |
| Rough Broken Land | C | 2,376 |
| Rough Mountainous Land | C | 9,978 |
| Rough Stony Land | C | 2,315 |
| Semiahmoo | D | 47 |
| Sinclair | B | 20 |
| Skykomish | A | 45 |
| Snohomish | B | 30 |
| Spanaway | A | 65 |
| Tanwax | A | 55 |
| Tisch | C | 16 |
| Wapato | C | 352 |
| Wilkeson | B | 5,280 |
| Water(Fresh) | - | 439 |
| Total | | 28,043 |
| **Mashel River 0-44 2/** | | |
| Barneston | A | 415 |
| Bellingham | D | 21 |
| Dupont | D | 10 |
| Everett | A | 1,279 |
| Greenwood(peat) | A | 2 |
| Kapowsin | B | 595 |
| Kopiah | D | 207 |
| Mukilteo | A | 170 |
| Pilchuck | A | 92 |
| Riverwash | A | 15 |
| Rough Broken Land | C | 3,384 |
| Rough Mountainous Land | C | 36,868 |
| Rough Stony Land | C | 270 |
| Semiahmoo | D | 15 |
| Sinclair | B | 78 |
| Tanwax | A | 5 |
| Wilkeson | B | 10,774 |
| Water(Fresh) | - | 34 |
| Total | | 54,234 |
| **Nisqually River 0-45 2/** | | |
| Alderwood | B | 4,341 |
| Barneston | A | 50 |
| Barneston-Wilkeson | A | 519 |
| Bellingham | D | 249 |
| Bow | D | 105 |
| Carbondale(muck) | D | 42 |
| Cathcart | C | 30 |
| Chehalis | A | 106 |
| Cinebar | B | 596 |
| Cispus | A | 330 |
| Clackamus | D | 140 |
| Delphi | B | 40 |
| Dupont | D | 79 |
| Edmonds | D | 8 |
| Eld | A | 20 |
| Everett | A | 25,241 |
| Everson | C | 1,603 |
| Fitch | A | 1,632 |
| Giles | B | 1,759 |
| Greenwater | A | 3,425 |
| Greenwood(peat) | A | 15 |
| Indianola | A | 968 |
| Kapowsin | B | 6,483 |
| Kitsap | C | 830 |
| Klaber | D | 362 |
| Kopiah | D | 180 |
| Lynden | A | 1,605 |
| McKenna | D | 1,038 |
| Melbourne | C | 5 |
| Mukilteo | A | 574 |
| National | A | 3,128 |
| Nesika | B | 1,893 |
| **Nisqually River (Con.)** | | |
| Newberg | A | 270 |
| Nisqually | A | 1,845 |
| Norma | C | 1,138 |
| Olympic | C | 38 |
| Pilchuck | A | 2,671 |
| Puget | B | 181 |
| Puyallup | B | 2,270 |
| Reed | D | 95 |
| Rifle(peat) | A | 419 |
| Riverwash | A | 920 |
| Rough Broken Land | C | 1,758 |
| Rough Mountainous Land | B | 9,188 |
| Rough Mountainous Land | C | 61,442 |
| Rough Stony Land | C | 136 |
| Schooley | C | 348 |
| Semiahmoo | D | 691 |
| Sinclair | B | 3,825 |
| Skykomish | A | 45 |
| Snohomish | B | 141 |
| Spanaway | A | 13,144 |
| Stossell | C | 2 |
| Sultan | B | 235 |
| Tacoma(muck) | B | 174 |
| Tenino | B | 2,679 |
| Tidal Marsh | B | 197 |
| Tisch | C | 1,056 |
| Tromp | B | 101 |
| Tumwater | A | 183 |
| Wapato | C | 140 |
| Wapato-Galvin | C | 40 |
| Wilkeson | B | 15,411 |
| Winston | A | 45 |
| Water(Fresh) | - | 5,454 |
| Water(Salt) | - | 970 |
| Total | | 184,648 |
| **DESCHUTES BASIN** | | |
| **Deschutes River 0-46 2/** | | |
| Alderwood | B | 3,830 |
| Bellingham | D | 20 |
| Camas | A | 347 |
| Cathcart | C | 1,102 |
| Chehalis | A | 1,665 |
| Delphi | B | 15 |
| Eld | A | 15 |
| Everett | A | 12,510 |
| Everson | C | 711 |
| Fitch | A | 1,604 |
| Giles | B | 4,227 |
| Greenwood(peat) | A | 20 |
| Indianola | A | 975 |
| Kapowsin | B | 820 |
| Kitsap | C | 140 |
| Lynden | A | 343 |
| Maytown | B | 45 |
| McKenna | D | 289 |
| Melbourne | C | 1,480 |
| Mukilteo | A | 726 |
| Newberg | A | 625 |
| Nisqually | A | 5,627 |
| Norma | C | 472 |
| Olympic | C | 7,734 |
| Prather | B | 15 |
| Reed | D | 369 |
| Rifle(peat) | A | 147 |
| Riverwash | A | 110 |
| Rough Mountainous Land | B | 23,766 |
| Rough Mountainous Land | C | 335 |
| Semiahmoo | D | 535 |
| Shuwah | A | 72 |
| Snohomish | B | 3 |
| Spanaway | A | 7,679 |
| Tacoma(muck) | B | 1 |
| Tenino | B | 155 |
| Tisch | C | 82 |
| Tromp | B | 80 |
| Tromp-Tisch | B | 30 |
| Tumwater | A | 3,124 |
| Wapato | C | 973 |
| **Deschutes River (Con.)** | | |
| Water(Fresh) | - | 817 |
| Total | | 83,635 |
| **Henderson Inlet Area 0-47 2/** | | |
| Alderwood | B | 4,646 |
| Bellingham | D | 1,285 |
| Chehalis | A | 10 |
| Edmonds | D | 15 |
| Everett | A | 14,895 |
| Everson | C | 205 |
| Fitch | A | 2,052 |
| Giles | B | 6,382 |
| Greenwood(peat) | A | 40 |
| Indianola | A | 2,188 |
| Kitsap | C | 11,381 |
| Lynden | A | 1,271 |
| Made Land | - | 310 |
| McKenna | D | 125 |
| Melbourne | C | 3 |
| Mukilteo | A | 1,755 |
| Nisqually | A | 3,859 |
| Norma | C | 66 |
| Puget | B | 62 |
| Puyallup | B | 1,087 |
| Rifle(peat) | A | 367 |
| Riverwash | A | 10 |
| Semiahmoo | D | 384 |
| Spanaway | A | 4,701 |
| Sultan | B | 765 |
| Tacoma(muck) | B | 345 |
| Tenino | B | 580 |
| Tidal Marsh | B | 435 |
| Tisch | C | 305 |
| Tromp | B | 286 |
| Tumwater | A | 2,689 |
| Water(Fresh) | - | 1,482 |
| Water(Salt) | - | 11,791 |
| Total | | 75,777 |
| **West Budd Inlet Area 0-48 2/** | | |
| Alderwood | B | 3,360 |
| Bellingham | D | 323 |
| Chehalis | A | 5 |
| Delphi | B | 365 |
| Edmonds | D | 31 |
| Eld | A | 178 |
| Everett | A | 5,021 |
| Everson | C | 213 |
| Fitch | A | 554 |
| Giles | B | 2,486 |
| Greenwood(peat) | A | 23 |
| Grove | A | 40 |
| Indianola | A | 30 |
| Kitsap | C | 1,890 |
| Lynden | A | 136 |
| Made Land | - | 40 |
| Maytown | B | 216 |
| McKenna | D | 239 |
| Melbourne | C | 125 |
| Mukilteo | A | 247 |
| Nisqually | A | 295 |
| Norma | C | 26 |
| Olympic | C | 365 |
| Puget | B | 323 |
| Rifle(peat) | A | 342 |
| Riverwash | A | 2 |
| Rough Mountainous Land | B | 3,575 |
| Semiahmoo | D | 31 |
| Spanaway | A | 15 |
| Sultan | B | 20 |
| Tenino | B | 959 |
| Tidal Marsh | B | 25 |
| Tisch | C | 7 |
| Tromp | B | 15 |
| Tumwater | A | 571 |
| Waddell | C | 66 |
| Wapato | C | 97 |
| Water(Fresh) | - | 283 |
| Water(Salt) | - | 4,557 |
| Total | | 27,096 |

Table 5. Soil series and hydrologic groups by watershed, Puget Sound Area (con.)

(in acres) 1/

| Soil Series | Hydrologic Group | Acres |
|---|---|---|
| **SAN JUAN ISLANDS** | | |
| Orcas-Waldron Islands 0-11 2/ | | |
| Alderwood | B | 1,477 |
| Bellingham | D | 687 |
| Bow | D | 5,176 |
| Coastal Beach | A | 340 |
| Coveland | C | 819 |
| Everett | A | 1,781 |
| Hovde | B | 19 |
| Indianola | A | 551 |
| Indianola-Roche | A | 917 |
| Neptune | A | 30 |
| Norma | C | 290 |
| Orcas (peat) | A | 5 |
| Pickett complex | C | 18,182 |
| Roche | D | 3,924 |
| Roche-Rock | D | 9,828 |
| Rock Land | D | 1,948 |
| San Juan | B | 35 |
| Semiahmoo | A | 55 |
| Semiahmoo | D | 278 |
| Tidal Marsh | B | 1 |
| Water(Fresh) | - | 484 |
| Water(Salt) | - | 93,862 |
| Total | | 140,689 |
| Stewart Islands 0-12 2/ | | |
| Active Dunes | B | 90 |
| Alderwood | B | 701 |
| Bellingham | D | 1,247 |
| Bow | D | 3,686 |
| Coastal Beach | A | 259 |
| Coveland | C | 4,461 |
| Everett | A | 688 |
| Hovde | B | 40 |
| Indianola | A | 406 |
| Norma | C | 318 |
| Orcas(peat) | A | 5 |
| Pickett complex | C | 381 |
| Roche | D | 8,287 |
| Roche-Rock | D | 12,132 |
| Rock Land | D | 3,615 |
| San Juan | A | 1,289 |
| San Juan | B | 663 |
| Semiahmoo | A | 71 |
| Semiahmoo | D | 734 |
| Tanwax | A | 5 |
| Tidal Marsh | B | 25 |
| Water(Fresh) | - | 279 |
| Water(Salt) | - | 131,494 |
| Total | | 170,876 |
| Lopez-Blakely-Decator Islands 0-13 2/ | | |
| Active Dunes | B | 26 |
| Alderwood | B | 1,160 |
| Bellingham | D | 37 |
| Bow | D | 4,412 |
| Coastal Beach | A | 414 |
| Coveland | C | 2,064 |
| Everett | A | 1,738 |
| Hovde | B | 20 |
| Indianola | A | 45 |
| Indianola-Roche | A | 347 |
| Neptune | A | 5 |
| Norma | C | 67 |
| Orcas(peat) | A | 45 |
| Pickett complex | C | 2,832 |
| Roche | D | 6,144 |
| Roche-Rock | D | 4,402 |
| Rock Land | D | 1,219 |
| San Juan | A | 265 |
| San Juan | B | 215 |
| Semiahmoo | A | 178 |
| Semiahmoo | D | 272 |
| Tanwax | A | 80 |
| Tidal Marsh | B | 140 |
| Water(Fresh) | - | 192 |
| Water(Salt) | - | 62,796 |
| Total | | 89,115 |

| Soil Series | Hydrologic Group | Acres |
|---|---|---|
| **ISLAND COUNTY** | | |
| North Island 0-16 2/ | | |
| Bellingham | D | 614 |
| Bozarth | C | 230 |
| Carbondale(muck) | D | 182 |
| Casey | C | 1,440 |
| Coastal Beach | A | 654 |
| Coupeville | B | 243 |
| Coveland | C | 1,952 |
| Ebeys | B | 118 |
| Fresh Water Marsh | A | 53 |
| Greenwood(peat) | A | 54 |
| Hovde | B | 121 |
| Hoypus | A | 11,598 |
| Keystone | A | 1,112 |
| Lummi | C | 502 |
| Made Land | - | 614 |
| Mukilteo | A | 286 |
| Norma | C | 1,076 |
| Pondilla | A | 135 |
| Rifle(peat) | A | 301 |
| Rough Broken Land | C | 323 |
| Rough Stony Land | C | 266 |
| San Juan | A | 135 |
| Semiahmoo | D | 443 |
| Snakelum | A | 10 |
| Swantown | C | 3,876 |
| Tacoma(peat) | A | 236 |
| Tanwax | A | 152 |
| Tidal Marsh | B | 101 |
| Townsend | B | 1,492 |
| Whidbey | A | 12,153 |
| Water(Fresh) | - | 259 |
| Total | | 40,731 |
| Camano Island 0-23 2/ | | |
| Alderwood | B | 12,343 |
| Bellingham | D | 650 |
| Bow | D | 2,800 |
| Coastal Beach | A | 443 |
| Coupeville | B | 8 |
| Coveland | C | 24 |
| Ebeys | B | 22 |
| Everett | A | 2,459 |
| Fresh Water Marsh | A | 20 |
| Hovde | B | 75 |
| Indianola | A | 3,960 |
| Lummi | C | 320 |
| Made Land | - | 53 |
| Mukilteo | A | 38 |
| Norma | C | 288 |
| Puget | B | 190 |
| Rifle(peat) | A | 82 |
| Rough Broken Land | C | 1,026 |
| Semiahmoo | D | 41 |
| Tacoma(peat) | A | 6 |
| Tanwax | A | 94 |
| Tidal Marsh | B | 316 |
| Townsend | B | 6 |
| Water(Fresh) | - | 60 |
| Total | | 25,324 |
| Central Island 0-24 2/ | | |
| Bellingham | D | 20 |
| Bozarth | C | 52 |
| Carbondale(muck) | D | 5 |
| Casey | C | 2,348 |
| Coastal Beach | A | 461 |
| Coupeville | B | 812 |
| Coveland | C | 108 |
| Ebeys | B | 511 |
| Hovde | B | 241 |
| Hoypus | A | 5,555 |
| Keystone | A | 2,691 |
| Made Land | - | 8 |
| Mukilteo | A | 64 |
| Norma | C | 357 |
| Pondilla | A | 28 |
| Rifle(peat) | A | 5 |
| Rough Broken Land | C | 549 |
| San Juan | A | 849 |

| Soil Series | Hydrologic Group | Acres |
|---|---|---|
| Central Island (Con.) | | |
| Semiahmoo | D | 22 |
| Snakelum | A | 495 |
| Swantown | C | 315 |
| Tacoma(peat) | A | 30 |
| Tanwax | A | 76 |
| Tidal Marsh | B | 944 |
| Townsend | B | 303 |
| Whidbey | A | 13,461 |
| Water(Fresh) | - | 76 |
| Total | | 30,386 |
| South Island 0-25 2/ | | |
| Bellingham | D | 66 |
| Carbondale(muck) | D | 5 |
| Casey | C | 321 |
| Coastal Beach | A | 484 |
| Greenwood(peat) | A | 45 |
| Hovde | B | 65 |
| Hoypus | A | 1,137 |
| Keystone | A | 11,703 |
| Lummi | C | 818 |
| Mukilteo | A | 537 |
| Norma | C | 887 |
| Rifle(peat) | A | 382 |
| Rough Broken Land | C | 962 |
| Rough Stony Land | C | 5 |
| Semiahmoo | D | 130 |
| Tacoma(peat) | A | 55 |
| Tanwax | A | 171 |
| Tidal Marsh | B | 126 |
| Townsend | B | 5 |
| Whidbey | A | 18,985 |
| Water(Fresh) | - | 324 |
| Total | | 37,213 |
| **WEST SOUND BASINS** | | |
| Skookum Creek 0-49 2/ | | |
| Alderwood | B | 3,987 |
| Bellingham | D | 1,203 |
| Carstairs | A | 30 |
| Cloquallum | C | 4,094 |
| Delphi | B | 3,759 |
| Edmonds | D | 1 |
| Eld | A | 491 |
| Everett | A | 3,547 |
| Everson | C | 90 |
| Fitch | A | 82 |
| Galvin | C | 55 |
| Giles | B | 1,703 |
| Gravel Pit | A | 5 |
| Grove | A | 3,447 |
| Indianola | A | 360 |
| Juno | A | 60 |
| Kitsap | C | 2,527 |
| Koch | D | 20 |
| Lynden | A | 55 |
| Lystair | A | 190 |
| Maytown | B | 453 |
| McKenna | D | 45 |
| McMurray(peat) | A | 25 |
| Mukilteo | A | 392 |
| Newberg | A | 21 |
| Nisqually | A | 20 |
| Norma | C | 155 |
| Olympic | C | 223 |
| Reed | D | 30 |
| Rifle(peat) | A | 21 |
| Rough Broken Land | C | 173 |
| Rough Mountainous Land | B | 12,385 |
| Rough Mountainous Land | C | 5,849 |
| Semiahmoo | D | 175 |
| Shelton | B | 6,772 |
| Sinclair | B | 55 |
| Spanaway | A | 75 |
| Sultan | B | 20 |
| Tanwax | A | 10 |
| Tebo | C | 393 |
| Tidal Marsh | B | 50 |
| Waddell | C | 772 |
| Wapato | C | 481 |

Table 5. Soil series and hydrologic groups by watershed, Puget Sound Area (con.)
(in acres) 1/

| Soil Series | Hydrologic Group | Acres |
|---|---|---|
| **WEST SOUND BASINS (Con.)** | | |
| Skookum Creek (Con.) | | |
| Water(Fresh) | - | 531 |
| Water(Salt) | - | 9,151 |
| Total | | 63,983 |
| Isabelle 0-50 2/ | | |
| Alderwood | B | 654 |
| Belfast | C | 5 |
| Belfast | D | 33 |
| Bellingham | D | 516 |
| Cloquallum | C | 3,845 |
| Delphi | B | 1,063 |
| Everett | A | 30 |
| Gravel Pit | A | 5 |
| Grove | A | 2,485 |
| Indianola | A | 105 |
| Lystair | A | 487 |
| Made Land | - | 55 |
| Maytown | B | 270 |
| McKenna | D | 17 |
| McMurray(peat) | A | 91 |
| Mukilteo | A | 375 |
| Norma | C | 25 |
| Nuby | C | 25 |
| Rough Broken Land | B | 590 |
| Rough Mountainous Land | C | 4,566 |
| Shelton | B | 5,874 |
| Sinclair | B | 55 |
| Tanwax | A | 5 |
| Tebo | C | 485 |
| Waddell | C | 60 |
| Wapato | C | 181 |
| Water(Fresh) | - | 338 |
| Water(Salt) | - | 686 |
| Total | | 22,926 |
| Anderson Island 0-51 2/ | | |
| Alderwood | B | 590 |
| Bellingham | D | 644 |
| Bow | D | 686 |
| Coastal Beach | A | 5 |
| Everett | A | 1,652 |
| Indianola | A | 10 |
| Kapowsin | B | 196 |
| Puget | B | 78 |
| Rough Broken Land | C | 252 |
| Sinclair | B | 864 |
| Tacoma(muck) | B | 55 |
| Water(Fresh) | - | 143 |
| Water(Salt) | - | 7,469 |
| Total | | 12,644 |
| McNeil Island 0-52 2/ | | |
| Alderwood | B | 2,396 |
| Bellingham | D | 250 |
| Everett | A | 335 |
| Indianola | A | 757 |
| Kapowsin | B | 322 |
| Mukilteo | A | 55 |
| Norma | C | 7 |
| Rough Broken Land | C | 95 |
| Water(Fresh) | - | 115 |
| Water(Salt) | - | 5,502 |
| Total | | 9,834 |
| Harstene Island 0-53 2/ | | |
| Bellingham | D | 217 |
| Coastal Beach | A | 40 |
| Everett | A | 1,120 |
| Gravel Pit | A | 2 |
| Grove | A | 1 |
| Harstene | B | 7,391 |
| Indianola | A | 288 |
| Kitsap | C | 620 |
| Mukilteo | A | 76 |
| Norma | C | 10 |
| Rough Broken Land | B | 388 |
| Harstene Island (Con.) | | |
| Sinclair | B | 3,399 |
| Tanwax | A | 26 |
| Tidal Marsh | B | 19 |
| Water(Salt) | - | 11,254 |
| Total | | 24,851 |
| Goldsborough Creek 0-54 2/ | | |
| Belfast | D | 225 |
| Bellingham | D | 318 |
| Carstairs | A | 1,633 |
| Cloquallum | C | 1,185 |
| Edmonds | D | 90 |
| Gravel Pit | A | 13 |
| Grove | A | 13,278 |
| Hoodsport | A | 1,045 |
| Juno | A | 175 |
| Koch | D | 74 |
| Lystair | A | 763 |
| Maytown | B | 50 |
| McKenna | D | 618 |
| McMurray(peat) | A | 400 |
| Mukilteo | A | 512 |
| Norma | C | 492 |
| Nuby | C | 100 |
| Orcas(peat) | A | 27 |
| Riverwash | A | 85 |
| Rough Broken Land | B | 270 |
| Rough Mountainous Land | B | 110 |
| Rough Mountainous Land | C | 1,567 |
| Semiahmoo | D | 130 |
| Shelton | B | 14,556 |
| Tanwax | A | 40 |
| Tebo | C | 335 |
| Waddell | C | 355 |
| Wapato | C | 55 |
| Water(Fresh) | - | 274 |
| Water(Salt) | - | 683 |
| Total | | 39,458 |
| Northwest Shelton 0-55 2/ | | |
| Alderwood | B | 57,335 |
| Alluvial Soils | A | 668 |
| Belfast | D | 35 |
| Bellingham | D | 695 |
| Carlsborg | A | 30 |
| Carstairs | A | 1,397 |
| Cathcart | C | 15 |
| Cloquallium | C | 3,977 |
| Coastal Beach | A | 110 |
| Edmonds | D | 5 |
| Eld | A | 80 |
| Everett | A | 22,349 |
| Gravel Pit | A | 20 |
| Greenwood(peat) | A | 105 |
| Grove | A | 4,761 |
| Harstene | B | 192 |
| Indianola | A | 1,608 |
| Juno | A | 42 |
| Kitsap | C | 593 |
| Koch | D | 45 |
| Lystair | A | 95 |
| Made Land | - | 26 |
| McKenna | D | 101 |
| McMurray(peat) | A | 983 |
| Mukilteo | A | 1,877 |
| Nordby | B | 10 |
| Norma | C | 308 |
| Nuby | C | 55 |
| Orcas(peat) | A | 307 |
| Riverwash | A | 20 |
| Rough Broken Land | B | 783 |
| Rough Broken Land | C | 204 |
| Rough Mountainous Land | C | 5 |
| Semiahmoo | D | 107 |
| Shelton | B | 683 |
| Sinclair | B | 2,595 |
| Spalding(peat) | D | 53 |
| Tanwax | A | 86 |
| Tebo | C | 3 |
| Tidal Marsh | B | 238 |
| Northwest Shelton (Con.) | | |
| Water(Fresh) | - | 2,421 |
| Water(Salt) | - | 12,050 |
| Total | | 117,072 |
| South Fork Skokomish 0-56 2/ | | |
| Alderwood | B | 3,062 |
| Dungeness | B | 2,781 |
| Everett | A | 40 |
| Gravel Pit | A | 3 |
| Grove | A | 3,630 |
| Hoodsport | A | 3,215 |
| Indianola | A | 143 |
| Lystair | A | 5 |
| Made Land | - | 10 |
| McMurray(peat) | A | 4 |
| Mukilteo | A | 564 |
| Nordby | B | 45 |
| Orcas(peat) | A | 76 |
| Pilchuck | A | 642 |
| Puget | B | 398 |
| Riverwash | A | 505 |
| Rough Broken Land | B | 30 |
| Rough Mountainous Land | B | 1,152 |
| Rough Mountainous Land | C | 3,910 |
| Semiahmoo | D | 3 |
| Shelton | B | 2,842 |
| Skokomish | B | 864 |
| Tacoma(peat) | A | 322 |
| Tanwax | A | 38 |
| Tidal Marsh | B | 140 |
| Water(Fresh) | - | 256 |
| Water(Salt) | - | 1,604 |
| Total | | 26,284 |
| North Fork Skokomish 0-57 2/ | | |
| Dungeness | B | 345 |
| Grove | A | 2,332 |
| Hoodsport | A | 7,717 |
| Hoodsport | B | 945 |
| Lystair | A | 30 |
| McMurray(peat) | A | 106 |
| Mukilteo | A | 48 |
| Nordby | B | 125 |
| Norma | C | 10 |
| Orcas(peat) | A | 8 |
| Pilchuck | A | 215 |
| Puget | B | 10 |
| Riverwash | A | 27 |
| Rough Mountainous Land | B | 2,639 |
| Rough Mountainous Land | C | 2,125 |
| Skokomish | B | 20 |
| Tanwax | A | 41 |
| Water(Fresh) | - | 2,457 |
| Total | | 19,200 |
| West Hood Canal 0-58 2/ | | |
| Bellingham | D | 15 |
| Cloquallum | C | 7 |
| Coastal Beach | A | 25 |
| Dungeness | B | 40 |
| Grove | A | 2,954 |
| Hoodsport | A | 13,663 |
| Hoodsport | B | 3,572 |
| Juno | A | 90 |
| Koch | D | 5 |
| Lystair | A | 80 |
| Made Land | - | 40 |
| McKenna | D | 7 |
| McMurray(peat) | A | 492 |
| Mukilteo | A | 108 |
| Nordby | B | 485 |
| Norma | C | 10 |
| Pilchuck | A | 95 |
| Puget | B | 95 |
| Riverwash | A | 10 |
| Rough Mountainous Land | B | 3,530 |
| Rough Mountainous Land | C | 3,372 |
| Semiahmoo | D | 10 |
| Shelton | B | 5 |

Table 5. Soil series and hydrologic groups by watershed, Puget Sound Area (con.)

(in acres) 1/

| Soil Series | Hydrologic Group | Acres |
|---|---|---|
| **WEST SOUND BASINS (Con.)** | | |
| West Hood Canal (Con.) | | |
| Skokomish | B | 35 |
| Tanwax | A | 37 |
| Tebo | C | 1 |
| Tidal Marsh | B | 105 |
| Water(Fresh) | - | 177 |
| Water(Salt) | - | 6,999 |
| Total | | 35,964 |
| Tahuya River 0-59 2/ | | |
| Alderwood | B | 17,031 |
| Alluvial Soils | A | 622 |
| Belfast | C | 140 |
| Belfast | D | 80 |
| Cloquallum | C | 278 |
| Coastal Beach | A | 25 |
| Everett | A | 6,144 |
| Greenwood(peat) | A | 62 |
| Indianola | A | 255 |
| Juno | A | 479 |
| Made Land | - | 1 |
| McMurray(peat) | A | 10 |
| Mukilteo | A | 98 |
| Norma | C | 40 |
| Nuby | C | 149 |
| Orcas(peat) | A | 40 |
| Riverwash | A | 20 |
| Rough Broken Land | B | 110 |
| Rough Mountainous Land | C | 2,581 |
| Tanwax | A | 93 |
| Tebo | C | 1 |
| Tidal Marsh | B | 40 |
| Water(Fresh) | - | 491 |
| Water(Salt) | - | 281 |
| Total | | 29,071 |
| North Hood Canal 0-60 2/ | | |
| Alderwood | B | 12,367 |
| Alluvial Soils | A | 307 |
| Belfast | C | 180 |
| Bellingham | D | 10 |
| Cloquallum | C | 50 |
| Coastal Beach | A | 22 |
| Edmonds | D | 185 |
| Everett | A | 11,210 |
| Gravel Pit | A | 30 |
| Greenwood(peat) | A | 90 |
| Indianola | A | 2,570 |
| Juno | A | 82 |
| Kitsap | C | 810 |
| Koch | D | 17 |
| Made Land | - | 20 |
| McKenna | D | 10 |
| Mukilteo | A | 339 |
| Nordby | B | 35 |
| Norma | C | 133 |
| Nuby | C | 10 |
| Orcas(peat) | A | 25 |
| Rifle(peat) | A | 269 |
| Rough Broken Land | B | 848 |
| Rough Mountainous Land | C | 2,485 |
| Saxon | C | 300 |
| Spalding(peat) | D | 67 |
| Tanwax | A | 63 |
| Tidal Marsh | B | 305 |
| Water(Fresh) | - | 362 |
| Water(Salt) | - | 4,145 |
| Total | | 37,346 |
| Carr Inlet Area 0-62 2/ | | |
| Alderwood | B | 21,053 |
| Alluvial Soils | A | 609 |
| Bellingham | D | 742 |
| Bow | D | 618 |
| Carbondale(muck) | D | 14 |
| Cathcart | C | 30 |
| Coastal Beach | A | 145 |
| Dupont | D | 25 |
| Carr Inlet Area (Con.) | | |
| Edmonds | D | 420 |
| Everett | A | 34,540 |
| Greenwood(peat) | A | 92 |
| Indianola | A | 5,598 |
| Kapowsin | B | 2,185 |
| Kitsap | C | 1,298 |
| Lynden | A | 162 |
| McKenna | D | 322 |
| McMurray(muck) | D | 59 |
| Mukilteo | A | 144 |
| Nisqually | A | 6 |
| Norma | C | 364 |
| Puyallup | B | 18 |
| Rifle(peat) | A | 265 |
| Rough Broken Land | C | 3,499 |
| Semiahmoo | D | 289 |
| Sinclair | B | 7,049 |
| Spalding(peat) | D | 10 |
| Steep Broken Land | B | 191 |
| Sultan | B | 9 |
| Tanwax | A | 21 |
| Tidal Marsh | B | 38 |
| Tisch | C | 5 |
| Water(Fresh) | - | 389 |
| Water(Salt) | - | 41,072 |
| Total | | 121,281 |
| Vashon Island 0-63 2/ | | |
| Alderwood | B | 16,516 |
| Alluvial Soils | A | 12 |
| Bellingham | D | 17 |
| Carbondale(muck) | D | 8 |
| Coastal Beach | A | 143 |
| Everett | A | 532 |
| Greenwood(peat) | A | 25 |
| Indianola | A | 366 |
| Kitsap | C | 235 |
| Lynden | A | 131 |
| Mukilteo | A | 5 |
| Norma | C | 89 |
| Ragnar | A | 3 |
| Rough Broken Land | C | 5,017 |
| Unclassified | - | 3 |
| Water(Fresh) | - | 3 |
| Water(Salt) | - | 27,816 |
| Total | | 50,921 |
| Hamma Hamma River 0-66 2/ | | |
| Cloquallum | C | 25 |
| Dungeness | B | 125 |
| Grove | A | 395 |
| Hoodsport | A | 1,433 |
| Hoodsport | B | 1,260 |
| Rough Broken Land | B | 10 |
| Rough Mountainous Land | C | 5,372 |
| Skokomish | B | 5 |
| Tidal Marsh | B | 69 |
| Water(Fresh) | - | 65 |
| Water(Salt) | - | 106 |
| Total | | 8,865 |
| Dosewallips-Duckabush 0-67 2/ | | |
| Ahl | B | 160 |
| Ahl complex | B | 1,242 |
| Belfast | D | 567 |
| Cloquallum | C | 63 |
| Coastal Beach | A | 22 |
| Ebeys | B | 18 |
| Grove | A | 1,431 |
| Hoodsport | A | 2,980 |
| Hoodsport | B | 3,585 |
| Hovde | B | 5 |
| Jolley | B | 5,823 |
| Kitsap | C | 27 |
| Lummi | C | 116 |
| Lystair | A | 95 |
| Maytown | B | 15 |
| Mukilteo | A | 35 |
| Olete | C | 19 |
| Dosewallips-Duckabush (Con.) | | |
| Olete complex | C | 319 |
| Riverwash | A | 71 |
| Rough Mountainous Land | C | 2,193 |
| Swantown | C | 23 |
| Tidal Marsh | B | 61 |
| Water(Fresh) | - | 90 |
| Water(Salt) | - | 2,054 |
| Total | | 21,014 |
| East Hood Canal 0-68 2/ | | |
| Alderwood | B | 26,957 |
| Alluvial Soils | A | 986 |
| Belfast | C | 6 |
| Belfast | D | 46 |
| Bellingham | D | 22 |
| Cloquallum | C | 25 |
| Coastal Beach | A | 26 |
| Edmonds | D | 45 |
| Everett | A | 18,209 |
| Greenwood(peat) | A | 85 |
| Indianola | A | 695 |
| Juno | A | 234 |
| Kitsap | C | 775 |
| Koch | D | 5 |
| McMurray(muck) | D | 30 |
| McMurray(peat) | A | 21 |
| Mukilteo | A | 202 |
| Norma | C | 10 |
| Nuby | C | 115 |
| Orcas(peat) | A | 37 |
| Riverwash | A | 9 |
| Rough Broken Land | B | 3,019 |
| Rough Mountainous Land | C | 405 |
| Saxon | C | 8 |
| Spalding(peat) | D | 138 |
| Steep Broken Land | B | 1,711 |
| Tanwax | A | 5 |
| Tidal Marsh | B | 15 |
| Water(Fresh) | - | 328 |
| Water(Salt) | - | 6,030 |
| Total | | 60,199 |
| West Kitsap Area 0-69 2/ | | |
| Alderwood | B | 35,244 |
| Alluvial Soils | A | 3,070 |
| Coastal Beach | A | 85 |
| Edmonds | D | 1,391 |
| Everett | A | 15,196 |
| Greenwood(peat) | A | 233 |
| Indianola | A | 9,085 |
| Kitsap | C | 5,112 |
| McMurray(muck) | D | 697 |
| Melbourne | C | 90 |
| Rifle(peat) | A | 315 |
| Rough Mountainous Land | C | 4,433 |
| Sinclair | B | 485 |
| Spalding(peat) | D | 187 |
| Steep Broken Land | B | 690 |
| Tidal Marsh | B | 25 |
| Water(Fresh) | - | 483 |
| Total | | 76,821 |
| East Kitsap Area 0-70 2/ | | |
| Alderwood | B | 37,988 |
| Alluvial Soils | A | 1,991 |
| Coastal Beach | A | 861 |
| Edmonds | D | 2,424 |
| Everett | A | 21,840 |
| Greenwood(peat) | A | 209 |
| Indianola | A | 16,227 |
| Kitsap | C | 4,333 |
| McMurray(muck) | D | 530 |
| Melbourne | C | 1,571 |
| Rifle(peat) | A | 1,113 |
| Sinclair | B | 1,993 |
| Spalding(peat) | D | 659 |
| Steep Broken Land | B | 3,125 |
| Tidal Marsh | B | 256 |
| Water(Fresh) | - | 527 |
| Total | | 95,647 |

Table 5. Soil series and hydrologic groups by watershed, Puget Sound Area (con.)

(in acres) 1/

| Soil Series | Hydrologic Group | Acres |
|---|---|---|
| **Quilcene** 0-71 2/ | | |
| Agnew | A | 29 |
| Ahl | B | 784 |
| Ahl complex | B | 1,131 |
| Alderwood | B | 5,034 |
| Belfast | D | 167 |
| Casey | C | 15 |
| Casey | D | 5 |
| Cathcart | C | 513 |
| Cloquallum | C | 243 |
| Coastal Beach | A | 142 |
| Colvos | B | 826 |
| Colvos complex | B | 486 |
| Daybob | B | 46 |
| Discovery Bay | C | 43 |
| Discovery Bay complex | A | 844 |
| Discovery Bay complex | C | 69 |
| Ebeys | B | 2 |
| Edmonds | D | 113 |
| Everett | A | 268 |
| Grove | A | 1,055 |
| Hoodsport | A | 2,859 |
| Hoodsport | B | 15 |
| Indianola | A | 20 |
| Jolley | B | 333 |
| Lummi | C | 125 |
| Lystair | A | 16 |
| Made Land | - | 11 |
| Maytown | B | 718 |
| McMurray(peat) | A | 174 |
| Mukilteo | A | 108 |
| Norma | C | 299 |
| Olete | C | 1,136 |
| Olete complex | C | 2,887 |
| Orcas(peat) | A | 22 |
| Quilcene | C | 1,494 |
| Reed | D | 190 |
| Riverwash | A | 20 |
| Semiahmoo | A | 78 |
| Semiahmoo | D | 25 |
| Sinclair | B | 80 |
| Snohomish | B | 186 |
| Swantown | C | 228 |
| Tacoma(peat) | A | 39 |
| Tidal Marsh | B | 145 |
| Water(Fresh) | - | 210 |
| Total | | 23,233 |
| **East Jefferson** 0-72 2/ | | |
| Active Dunes | B | 156 |
| Agnew | A | 2,530 |
| Alderwood | B | 17,773 |
| Bozarth | C | 167 |
| Casey | D | 306 |
| Cathcart | C | 1,039 |
| Chimacum | A | 5,832 |
| Clallam | C | 10,885 |
| Coastal Beach | A | 1,335 |
| Colvos | B | 2,705 |
| Colvos complex | B | 2,549 |
| Daybob | B | 6,872 |
| Dick | A | 686 |
| Dick complex | A | 326 |
| Discovery Bay | C | 2,018 |
| Discovery Bay complex | A | 2,215 |
| Discovery Bay complex | C | 1,339 |
| Ebeys | B | 105 |
| Edmonds | D | 651 |
| Everett | A | 4,639 |
| Grove | A | 426 |
| Hoodsport | A | 1,137 |
| Hovde | B | 122 |
| Hoypus | A | 1,013 |
| Indianola | A | 1,292 |
| Keystone | A | 1,205 |
| Kitsap | C | 2,563 |
| Lummi | C | 137 |
| Lystair | A | 168 |
| Made Land | - | 474 |
| Maytown | B | 565 |
| McMurray(peat) | A | 504 |
| Mukilteo | A | 835 |

| Soil Series | Hydrologic Group | Acres |
|---|---|---|
| **East Jefferson (Con.)** | | |
| Norma | C | 1,001 |
| Olete | C | 2,870 |
| Olete complex | C | 3,004 |
| Orcas(peat) | A | 20 |
| Quilcene | C | 1,749 |
| Reed | D | 343 |
| Rough Mountainous | A | 680 |
| San Juan | A | 698 |
| Semiahmoo | A | 257 |
| Semiahmoo | D | 306 |
| Sinclair | B | 20,324 |
| Snohomish | B | 11 |
| Swantown | C | 939 |
| Tacoma(peat) | A | 148 |
| Tidal Marsh | B | 1,074 |
| Tisch | C | 5 |
| Townsend | B | 452 |
| Wapato | C | 118 |
| Whidbey | A | 4,694 |
| Water(Fresh) | - | 463 |
| Total | | 113,725 |
| **Chimacum** 0-73 2/ | | |
| Agnew | A | 717 |
| Alderwood | B | 6,575 |
| Alderwood complex | B | 191 |
| Casey | D | 145 |
| Cathcart | C | 81 |
| Chimacum | A | 1,219 |
| Clallam | C | 1,271 |
| Coastal Beach | A | 29 |
| Colvos | B | 1,396 |
| Colvos complex | B | 863 |
| Dick | A | 139 |
| Dick complex | A | 125 |
| Discovery Bay | C | 450 |
| Discovery Bay complex | A | 376 |
| Discovery Bay complex | C | 677 |
| Dupont | D | 4 |
| Ebeys | B | 42 |
| Edmonds | D | 446 |
| Everett | A | 700 |
| Galvin | C | 10 |
| Hoodsport | A | 32 |
| Indianola | A | 483 |
| Kitsap | C | 220 |
| Made Land | - | 9 |
| Maytown | B | 172 |
| McMurray(peat) | A | 108 |
| Mukilteo | A | 230 |
| Norma | C | 322 |
| Quilcene | C | 39 |
| Reed | D | 61 |
| San Juan | A | 223 |
| Semiahmoo | A | 395 |
| Semiahmoo | D | 1,176 |
| Sinclair | B | 2,742 |
| Snohomish | B | 23 |
| Swantown | C | 403 |
| Tisch | C | 187 |
| Wapato | C | 5 |
| Whidbey | A | 40 |
| Water(Fresh) | - | 108 |
| Total | | 22,434 |
| **Sequim Bay Area** 0-75 2/ | | |
| Agnew | A | 193 |
| Alderwood | B | 164 |
| Bellingham | D | 166 |
| Chehalis | A | 72 |
| Chimacum | A | 30 |
| Clallam | C | 9,804 |
| Coastal Beach | A | 67 |
| Everett | A | 620 |
| Norma | C | 7 |
| Olete | C | 191 |
| Olete complex | C | 200 |
| Rough Mountainous Land | A | 2,969 |
| Semiahmoo | A | 62 |
| Spalding(peat) | A | 7 |

| Soil Series | Hydrologic Group | Acres |
|---|---|---|
| **Sequim Bay Area (Con.)** | | |
| Tidal Marsh | B | 19 |
| Water(Fresh) | - | 23 |
| Total | | 14,594 |
| **Johnson Creek** 0-76 2/ | | |
| Agnew | A | 588 |
| Bellingham | D | 423 |
| Carlsborg | A | 51 |
| Chehalis | A | 85 |
| Clallam | C | 8,259 |
| Coastal Beach | A | 75 |
| Elwha | C | 258 |
| Everett | A | 246 |
| Rough Mountainous Land | A | 4,097 |
| Semiahmoo | A | 62 |
| Sequim | A | 1,046 |
| Spalding(peat) | A | 42 |
| Tidal Marsh | B | 75 |
| Water(Fresh) | - | 11 |
| Total | | 15,318 |
| **ELWHA AND DUNGENESS BASINS** | | |
| **Dungeness River** 0-77 2/ | | |
| Agnew | A | 1,369 |
| Bellingham | D | 1,205 |
| Carlsborg | A | 2,585 |
| Chehalis | A | 2 |
| Clallam | C | 7,127 |
| Coastal Beach | A | 1,122 |
| Dick | A | 2,278 |
| Dungeness | B | 5,796 |
| Elwha | C | 2,752 |
| Everett | A | 1,027 |
| Pilchuck | A | 1,163 |
| Puget | B | 1,149 |
| Rifle(peat) | A | 45 |
| Riverwash | A | 378 |
| Rough Mountainous Land | A | 4,189 |
| Semiahmoo | A | 255 |
| Sequim | A | 1,438 |
| Spalding(peat) | A | 185 |
| Tidal Marsh | B | 110 |
| Townsend | B | 83 |
| Water(Fresh) | - | 204 |
| Total | | 34,462 |
| **McDonald Creek** 0-78 2/ | | |
| Agnew | A | 1,250 |
| Bellingham | D | 217 |
| Clallam | C | 4,107 |
| Dick | A | 410 |
| Dungeness | B | 180 |
| Elwha | C | 1,916 |
| Everett | A | 210 |
| Greenwood(peat) | A | 7 |
| Pilchuck | A | 3 |
| Riverwash | A | 55 |
| Rough Broken Land | A | 660 |
| Rough Mountainous Land | A | 1,804 |
| Semiahmoo | A | 8 |
| Water(Fresh) | - | 4 |
| Total | | 10,831 |
| **Siebert Creek** 0-79 2/ | | |
| Agnew | A | 1,070 |
| Bellingham | D | 443 |
| Chehalis | A | 2 |
| Clallam | C | 4,016 |
| Dick | A | 210 |
| Elwha | C | 2,789 |
| Everett | A | 633 |
| Greenwood(peat) | A | 6 |
| Rifle(peat) | A | 113 |
| Rough Broken Land | A | 1,948 |
| Rough Mountainous Land | A | 514 |
| Semiahmoo | A | 83 |
| Spalding(peat) | A | 5 |

Table 5. Soil series and hydrologic groups by watershed, Puget Sound Area (con.)
(in acres) 1/

| Soil Series | Hydrologic Group | Acres |
|---|---|---|
| **ELWHA-DUNGENESS BASINS (Con.)** | | |
| Siebert Creek (Con.) | | |
| Water (Fresh) | - | 2 |
| Total | | 11,834 |
| **MORSE CREEK** 0-80 2/ | | |
| Agnew | A | 167 |
| Bellingham | D | 525 |
| Clallam | C | 6,744 |
| Coastal Beach | A | 84 |
| Dungeness | B | 95 |
| Elwha | C | 2,673 |
| Everett | A | 1,400 |
| Pilchuck | A | 38 |
| Puget | B | 30 |
| Rifle (peat) | A | 4 |
| Riverwash | A | 33 |
| Rough Broken Land | A | 2,525 |
| Rough Mountainous Land | A | 3,173 |
| Semiahmoo | A | 44 |
| Spalding Peat | A | 45 |
| Water (Fresh) | - | 29 |
| Total | | 17,609 |

| Soil Series | Hydrologic Group | Acres |
|---|---|---|
| Ennis Creek 0-81 2/ | | |
| Agnew | A | 37 |
| Bellingham | D | 68 |
| Chehalis | A | 52 |
| Clallam | C | 934 |
| Coastal Beach | A | 32 |
| Crescent | B | 12 |
| Elwha | C | 585 |
| Everett | A | 211 |
| Rifle (peat) | A | 4 |
| Rough Broken Land | A | 460 |
| Rough Mountainous Land | A | 1,495 |
| Semiahmoo | A | 5 |
| Total | | 3,895 |
| Port Angeles 0-82 2/ | | |
| Agnew | A | 468 |
| Agnew-Elwha complex | C | 463 |
| Bellingham | D | 376 |
| Chehalis | A | 57 |
| Clallam | C | 1,487 |
| Coastal Beach | A | 441 |
| Crescent | B | 39 |
| Dick | A | 5 |
| Elwha | C | 6,611 |
| Everett | A | 393 |

| Soil Series | Hydrologic Group | Acres |
|---|---|---|
| Port Angeles (Con.) | | |
| Rifle (peat) | A | 7 |
| Rough Broken Land | A | 826 |
| Rough Mountainous Land | A | 5,004 |
| Semiahmoo | A | 10 |
| Spalding (peat) | A | 53 |
| Water (Fresh) | - | 8 |
| Total | | 16,248 |
| Elwha River 0-83 2/ | | |
| Agnew | A | 106 |
| Agnew-Elwha complex | C | 298 |
| Coastal Beach | A | 86 |
| Crescent | B | 896 |
| Dungeness | B | 226 |
| Elwha | C | 1,314 |
| Everett | A | 468 |
| Pilchuck | A | 481 |
| Puget | B | 25 |
| Rifle (peat) | A | 232 |
| Riverwash | A | 313 |
| Rough Broken Land | A | 648 |
| Rough Mountainous Land | A | 8,573 |
| Spalding (peat) | A | 19 |
| Water (Fresh) | - | 718 |
| Total | | 14,403 |

1/ Unadjusted measurements, 1966, for Puget Sound Area Study, based on National Cooperative Soil Survey maps. Does not include land within national forest or national park boundaries.

2/ See Figure 1 for location.

## SOIL ASSOCIATIONS

Grouping of the soils at the series level of classification into soil associations provides a basis for showing the general areal distribution of the soils. (See Figure 3, Generalized Soils Map, Puget Sound Area).

A soil association is controlled by geography rather than by similarities of soil properties. It is useful for describing the location and extent of soils. Within an association, the soil series have a distinctive pattern of occurrence that gives the landscape character. For example, one soil may be nearly level and poorly drained but associated with inter-related soils characterized by undulating or rolling topography.

Soils of each mapped association are described here as to their topographic occurrence, drainage, and general profile characteristics. The area of occurrence of each soil is indicated by percent in the narrative description. This percentage provides the means to approximate the weighted composite characteristics of the geographic area. For detailed descriptions of soil series and types, the published soil survey reports by counties should be consulted.

### Descriptions

#### Squalicum-Whatcom-Kickerville-Barnhardt Soil Association (A02)[1]

These are moderately well and well drained, moderately deep soils, overlying slowly permeable cemented glacial clay till and glacial gravelly sandy till. The soils have formed at elevations which range from 100 to 3,000 feet, in a climatic zone having annual precipitation of 50 to 75 inches.

Soils in this association are: Squalicum, 23 percent, Whatcom, 13 percent; Oso, 12 percent; Kickerville, 9 percent; Barneston, 3 percent; Barnhardt, 4 percent; Bellingham, 1 percent; Bow, 1 percent; Cagey, 4 percent; Cathcart, 2 percent; Custer, 1 percent; Everson, 1 percent; Giles, 1 percent; Labounty, 5 percent; McKenna, 2 percent; McMurray, 4 percent; Norma, 1 percent; and Puyallup, 4 percent. Other soils which occur in this association are: Clipper, Edmonds, Heisler, Hemmi, Hovde, Indianola, Kline, Lynden, Mukilteo, Neptune, Nooksack, Pilchuck, Samish, Salal, Saxon, Semiahmoo, Skagit, Smith Creek, Snohomish, Tromp, Wickersham, and Woodlyn.

[1] Association identification on Generalized Soils Map.

Barnhardt soils occur on high glacial moraine foothill areas with undulating, rolling, hilly, and steep topography. Cathcart soils occur on glacially scoured foothills. Squalicum soils occur on glacial moraines in the high foothills. Whatcom and Kickerville soils occur on low ground moraines generally characterized by kettle and kame topography. Labounty soils occur in imperfectly drained basins, and Whatcom soils occur on moraines and kettle and kames. McKenna soils occupy poorly drained basins. The soils occur at elevations of from about 80 feet to 400 feet in an annual precipitation zone of 45 to 50 inches.

**Whatcom-Labounty-Cagey-McKenna-Norma Soil Association (A03)**

Nearly level, undulating, rolling and hilly, moderately shallow and shallow, moderately well, imperfectly and poorly drained, moderately fine textured soils make up this association. These soils have medium and moderately fine textured surfaces and silty clay loam subsoils overlying dense, compact clay and silty clay basal till. The association includes areas of very poorly drained and poorly drained basin soils.

Soils in this association are: Whatcom, 25 percent; Labounty, 12 percent; Cagey, 8 percent; McKenna, 5 percent; Norma, 5 percent; Bellingham, 3 percent; Bow, 3 percent; Custer, 1 percent; Giles, 2 percent; Hale, 1 percent; Kickerville, 4 percent; Lynden, 2 percent; McMurray, 3 percent; and Puyallup, 1 percent. Other soils in this association are: Barneston, Barnhardt, Cathcart, Clipper, Edmonds, Everson, Hemmi, Hovde, Indianola, Kline, Lummi, Mukilteo, Neptune, Nooksack, Oso, Pilchuck, Puget, Salal, Saxon, Schnorbush, Semiahmoo, Smith Creek, Snohomish, Squalicum, Sumas, Tromp, and Woodlyn.

Whatcom soils occur on low ground moraines with kettle and kame topography. Labounty and Cagey soils occupy somewhat poorly drained basin, undulating and rolling areas, and Bellingham, McKenna, Norma, Hale, and Woodlyn soils occupy poorly drained basins. Organic soils occupy very poorly drained basins. The soils occur at elevations between 100 and 200 feet, in a climatic zone with annual precipitation between 30 and 35 inches.

**Pickett-Rockland Soil Association (A04)**

The topography is hilly to precipitous. Generally, the soils are moderately deep to shallow silt loams and loams overlying sandstone and argillite bedrock. Many Rockland and Rock Outcrop areas occur within the association. The soils have formed under 25 to 30 inches of annual precipitation.

Soils included in this association are: Pickett, 85 percent; Rockland, 8 percent; and Rock Outcrop, 3 percent; with small areas of Semiahmoo, Orcas and Tanwax series.

**Lynden-Custer-Giles Soil Association (A05)**

Gently sloping, undulating and hilly, somewhat excessively drained, well drained, imperfectly and poorly drained soils on glacial outwash terraces make up this soil association. The soils have formed under a precipitation of 45 to 50 inches annually.

Soils included in this association are: Lynden, 23 percent; McMurray, 16 percent; Custer, 12 percent; Giles, 12 percent; Edmonds, 3 percent; Everson, 2 percent; Nooksack, 2 percent; Puyallup, 3 percent; Tromp and Tromp Complex with Norma, 10 percent; and Woodlyn, 4 percent. Other soils included in this association are: Barneston, Bellingham, Bow, Cagey, Cathcart, Hale, Hemmi, Indianola, Kickerville, Kline, Labounty, McKenna, Mukilteo, Norma, Pilchuck, Puget, Saxon, Schnorbush, Semiahmoo, Smith Creek, Snohomish, Sumas, and McKenna.

Lynden, Giles, and Indianola series are sandy and silty glacial outwash soils on undulating and hilly areas. The Custer, Cagey, and Tromp series are gently sloping, imperfectly to poorly drained, moderately deep to shallow basin soils, with iron cemented sandy subsoils. Bellingham, Everson, Hemmi, McKenna, and Woodlyn are gently sloping, poorly drained basin soils with silty clay and clay subsoils. These basin soils occur in the low, poorly drained areas within the Lynden, Custer, and Giles soil series association.

**Puyallup-Puget-Nooksack-Pilchuck Soil Association (A08)**

This association consists of nearly level, well drained, somewhat excessively drained, and imperfectly drained bottom lands, subject to periodic overflow. Also included in the association are adjacent terraces and uplands.

The soils have silt loam, clay loam, sandy loam, and sandy surfaces, and overlie clay loam, fine sandy loam, and sandy subsoils. The soils occur in a climatic zone having 35 to 45 inches precipitation annually.

Soils included in this association are: Puyallup, 29 percent; Puget, 9 percent; Nooksack, 7 percent; Pilchuck, 7 percent; McMurray, 3 percent; Barneston, 4 percent; Heisler, 2 percent; Oso Rough Mountainous Lands (which are adjacent to the bottom lands), 11 percent; Squalicum, 1 percent; and Alderwood/Squalicum Complex, 10 percent. Other soils included in this association are: Bellingham, Bow, Cagey, Clipper, Custer, Giles, Hale, Indianola, Kickerville, Kline, Labounty, Lummi, Lynden, McKenna, Norma, Saxon, Schnorbush, Semiahmoo, Skagit, Smith Creek, Snohomis, Thornton, Whatcom, and Wickersham.

**Barneston-Oso-Smith Creek Soil Association (A09)**

These are nearly level to hilly, moderately shallow and shallow, somewhat excessively, well and poorly drained terrace and bottom land soils overlying sand and gravel, and basal till. The soil series in this association are: Barneston, 37 percent; Cagey, 2 percent; Clipper, 2 percent, Heisler, 3 percent; Kline, 2 percent; Oso, 35 percent; Pilchuck, 2 percent; Puyallup, 1 percent; Smith Creek, 3 percent; Squalicum and Squalicum/Alderwood Complex, 3 percent; and Wickersham, 1 percent.

Soils of the Barneston, Barnhardt, Lynden, and Smith Creek series are gravelly sandy ablation till soils. Soils of the Bow, Saxon, Squalicum, and Whatcom series are basal till soils, with cemented gravelly sandy and clay substrata. The Oso series is a basal till soil overlying sandstone bedrock at shallow depths. The soils occur in a climatic zone, having annual precipitation of 45 to 60 inches.

**Rough Mountainous-Oso Soil Association (A10)**

These are steep to very steep, moderately well and well drained, thin mantle soils, overlying sandstone and shale bedrock. In places, a thin layer of basal till may overlie the bedrock. Thickness of the soil mantle is extremely variable. Numerous Rock Outcrop areas occur on the steep and precipitous slopes. The soils occur at elevations from about 100 feet to more than 8,000 feet, in a climatic zone having an annual precipitation of 50 to more than 100 inches. Descriptions of the soils can be found in a reconnaissance soil survey prepared by the U. S. Forest Service, as well as in sources previously mentioned.

Soils included in this association are: Rough Mountainous and Oso soil materials, 99 percent.

**Alderwood-Everett-Kitsap Soil Association (A14)**

Soils of this association occur on nearly level, undulating, rolling, hilly and steep topography. They are well drained, moderately well drained, and poorly drained glacial terraces and uplands with cemented basal till, loose glacial till outwash materials, and glacial marine terraces, with their associated poorly drained and very poorly drained basins. The soils occur at elevations from near sea level to about 600 feet, in a climatic zone having annual precipitation of 30 inches at sea level to more than 70 inches at higher elevations.

Alderwood soils make up about 60 percent of the association; Barneston, 1 percent; Bellingham, 1 percent; Everett, 9 percent; Indianola, 2 percent; Kitsap, 5 percent; McMurray, 2 percent; Puget, 1 percent; and rough broken

and rough stony lands, 3 percent. Other soils, which occur on about 4 percent of the association, are: Cathcart, Edgewick, Edmonds, Issaquah, Lynden, Mukilteo, Pilchuck, Puyallup, Salal, Sammamish, Snohomish Snoqualmie, Sultan, Woodinville, and Orcas.

Alderwood soils occupy the glacial uplands underlain by strongly cemented basal till. Everett soils occupy glacial outwash uplands underlain by loose, porous gravels and sands. Kitsap soils are closely associated with the Alderwood soils from a topography standpoint, and they are derived from glacial lake and marine terraces. Other soils of the glacial outwash materials are: Barneston, Indianola, Lynden, and Snoqualmie. Soils occupying poorly drained basin positions are: Bellingham and Norma. The poorly drained basin areas are occupied by the organic soils, which are: McMurray, Mukilteo, and Orcas. Bottom land soils within the association which are subject to periodic flooding are: Edgewick, Issaquah, Pilchuck, Puget, Puyallup, Salal, Sammamish, Snohomish, Sultan, and Woodinville.

**Roche-Bow-Coveland Soil Association (A15)**

These are imperfectly drained, moderately deep, basal clay till and marine clay terrace soils and their associated poorly drained bains. They have loam, gravelly loam and clay loam surfaces overlying dense, silty clay loams and clay substrata. The soils occur at elevations from sea level to 500 to 800 feet in a mild, marine climate, with annual precipitation of 22 to 24 inches.

Soils of this association are: Roche-Rockland complex, 30 percent; Roche, 20 percent; Bow, 15 percent; Coveland, 8 percent; Rockland, 6 percent; Everett, 4 percent; Alderwood, 4 percent; San Juan, 3 percent; Bellingham, 2 percent; Semiahmoo, 2 percent; Rockland, 1 percent; and Everett-Indianola, 1 percent.

Other soils which occur on 4 percent of the area are: Hovde, Indianola, Neptune, Norma, Orcas, Pickett-Rock Outcrop, and Tanwax.

Roche soils occur on stratified, dense, basal till on undulating to steep topography, and Bow soils occur on massive, dense, basal clay till, on undulating to rolling topography. Everett, Indianola, and San Juan soils are deep, ablation, gravelly and sandy till soils on rolling and hilly topography. Within these areas are poorly drained basins of Bellingham, Coveland, Norma, Hovde, Semiahmoo, Tanwax and Orcas series.

**Puyallup-Pilchuck-Puget-Riverwash Soil Association (A18)**

Soils of this association occur on bottom lands which are subject to frequent overflow. They are moderately coarse and coarse textured and somewhat excessively drained, and they occur on nearly level topography, at elevations

of less than 25 feet to about 600 feet, in a climatic zone having annual precipitation ranging between 30 and 80 inches. The soils are subject to overflow during periods of excess precipitation.

Bottom land soils, which are subject to frequent overflow, occur on 68 percent of the area. Distribution of the occurrence of the bottom land soils are: Puyallup, 34 percent; Pilchuck, 6 percent; Puget, 8 percent; Riverwash, 9 percent; Sumas, 8 percent; Kline, 1 percent. Other bottom land soils which occur on 2 percent of the area are: Cokedale, Lummi, Samish, Snohomish, Sultan, Tanwax, and Woodinville. Other upland and glacial terrace soils which occur on 22 percent of the association are: Everett, 1 percent; Greenwater, 1 percent; Heisler, 7 percent; Indianola, 1 percent; Klaus, 2 percent; Lynden, 3 percent; Marblemount, 2 percent; Oso, 1 percent; Thornwood, 1 percent; and Rough Stony Lands, 4 percent. Upland, upland terraces, and terrace basins, which occur on 11 percent of the association are: Alderwood, Bellingham, Cagey, Cathcart, Edmonds, Everett, Giles, Gilligan, Heisler, Kitsap, Marblemount, McMurray, Mukilteo, Semiahmoo, Skiyou, Squalicum, Thornton, Thornwood, Wickersham, Norma, and Oso.

**Rough Mountainous Lands-Crescent-Sandstone Soil Materials Soil Association (A20)**

This association of soils consist of steep, rough mountainous areas, dominated rock lands, rock outcrops and talus slopes.

The Crescent series are shallow loam soils overlying sandstone alluvial fans. Other soils in the area have not been classified. The area occurs in a climatic zone having 50 to 100 inches annual precipitation.

**Rough Mountainous-McLeod-Marblemount Soil Association (A21)**

These are steep and very steep mountain slopes and valleys of the west slope of the Cascade Mountains. In this association the soil mantle is very thin over granite, granodiorite, and other acidic rocks. The soils are formed under an annual precipitation of 70 to 100 inches and they occur at elevations between 1,000 and 10,000 or 12,000 feet.

Soils included in this association are: McLeod, Marblemount, and other uncorrelated and unnamed series.

**Custer-Lynden-Norma Soil Association (A23)**

Soils of this association are nearly level and undulating, poorly drained, and somewhat excessively drained. The Custer soils are underlain by sandy loams that are cemented; the Lynden soils are underlain by loose glacial outwash

sands; and the Norma soils are in basin positions and are underlain by clay loam or clay. The soils occur at elevations between 30 and 100 feet, in a climatic zone having annual precipitaion between 30 and 50 inches.

Soils included in this association are: Custer, 28 percent; Lynden, 46 percent; Norma, 18 percent; McMurray, 4 percent; and Puget, 2 percent. Rough broken lands, Alderwood, Orcas, and Mukilteo series occur on the remaining 2 percent of the association.

**Puget-Snohomish-Puyallup Soil Association (A28)**

Soils of this association occur on nearly level to basin-like topography, and are very poorly drained to somewhat excessively drained bottom lands of the Skagit, Stillaguamish, Samish, Snohomish, and Skykomish Rivers. The soils are subject to periodic overflow and flooding during periods of excess precipitation. They occur at elevations from near sea level to 500 feet in a climatic zone having annual precipitation which ranges between 30 and 70 inches.

Bottom land soils of this association occur on 78 percent of the area. Soils included inthe bottom land portion of the association are: Puget, 47 percent; Snohomish, 8 percent; Puyallup, 7 percent; Sultan, 2 percent; Lummi, 2 percent; and Riverwash, 10 percent. Other bottom lands soils which occur on less than 1 percent of the association are: Kline, Neptune, Samish, and Woodinville.

Upland, terrace, and terrace basin soils which occur in the association are: Alderwood, 1 percent; Everett, 1 percent; Lynden, 2 percent; McMurray, 2 percent; Mukilteo, 2 percent; Ragnar, 8 percent; and Rough Broken, and Rough Stony lands, 3 percent. Other upland and terrace soils which occur on 8 percent of the association are: Bellingham, Bow, Custer, Edmonds, Giles, Indianola, Kitsap, Klaus, Kline, Norma, Orcas, Oso, and Snoqualmie.

**Rough Mountainous Lands-Heisler-Thornwood (Schist, Argillite and Gneiss) Soil Association (A31)**

This association consists of steep to hilly, very shallow to deep, well drained mountainous lands, on Schist, Argillite and Gneiss bedrock. The soils are Heisler, Blethen, and Thornwood series. The Heisler series occur on alluvial fans from the steep mountain slopes; the Thornwood series occur as ablation till in the foothills; and the Blethen series occur in the mountainous areas. Other soil series which occur in the association are: Cathcart, Everett, Giles, Gilligan, Greenwater, Klaus, Lynden, Oso, and Skiyou. The association occurs at elevations of about 500 to about 6,000 feet in a climatic zone having annual precipitation of 70 to 120 inches.

**Everett-Barneston-Indianola-Alderwood Soil Association (A36)**

Included in this association are somewhat excessively drained, glacial outwash, sandy and gravelly soils occurring on topography that is dominantly nearly level, undulating, rolling, hilly, and steep.

Distribution of soils within the association are: Everett, 30 percent; Barneston, 28 percent; Alderwood, 11 percent; Indianola, 4 percent; Rough Broken, Rough Stony, and Rough Mountainous lands, 10 percent; Lynden, 3 percent; Snoqualmie, 2 percent; Norma, 1 percent; and Puyallup, 1 percent. Other soils which occur on 5 percent of the area are: Bellingham, Cathcart, Custer, Edmonds, Kitsap, Klaus, Mukilteo, Orcas, Oso, Pilchuck, Puget, Sammamish, Snohomish, and Stossel.

The association occurs from near sea level to 600 feet in elevation in a climatic zone having 35 to 60 inches annual precipitation.

**Fidalgo-Rockland Soil Association (A41)**

This association consists of gently sloping to steep, shallow to moderately deep soils on serpentine-like bedrock. Soil series in this association are: Fidalgo, 41 percent; and Rockland (Fidalgo soil materials), 55 percent. Other soil series included in the association are: Alderwood, Bellingham, Bow, Lummi, McMurray, Puyallup, and Semiahmoo.

The Fidalgo series and associated Rocklands are shallow, well drained rocky soils, rocklands and rock outcrops. The association occurs at elevations from sea level to about 1,300 feet in a climatic zone having annual precipitation of 25 to 30 inches.

**Rough Mountainous-Wilkeson Soil Association (A51)**

Soils of this association occur on steep and very steep mountainous slopes which have a mantle of various thicknesses of volcanic ash overlying andesite, basalt, and volcanic tuff rocks. They occur at elevations ranging between 1,000 and 12,000 or 14,000 feet.

Soils included in this association are: Wilkeson, Teneriffe, and Blethen. The latter two soils are uncorrelated.

**Rough Mountainous Lands-Olympic Soil Materials Soil Association (A61)**

Soils of this association occur on rolling, steep, and very steep mountain slopes and valleys. The soils are formed from andesite and basalt volcanic rocks. The materials are the source of Olympic soils.

**Rough Mountainous Lands-Melbourne Soil Materials Soil Association (A71)**

This association consists of rough mountainous lands on sandstone and shale bedrock. Soil series are dominantly in the Melbourne series which are moderately deep, well drained, upland soils on soft shale bedrock. The topography ranges from rolling to steep. The association occurs in a climatic zone having 45 to 70 inches annual precipitation.

**Rough Mountainous Lands-Tebo-Ahl Soil Association (A81)**

The soils are formed on rolling, hilly, steep and very steep mountain slopes and valleys, under a climatic zone having precipitation of 70 to more than 100 inches annually. They occur at elevations from about 500 to more than 7,000 feet.

The soils included in this association are: Tebo, Ahl, Delphi, Elinor, and other unclassified, uncorrelated soils.

**Discovery Bay-Olele-Ahl Soil Association (A91)**

This association consists of hilly to steep, well drained, shallow to deep soils on basalt bedrock and conglomerate. The soils in the association are: Discovery Bay, 36 percent; Olele, 38 percent; Ahl, 15 percent; Alderwood, 3 percent; and Hoodsport, 3 percent. Other soil series in the association are: Agnew, Clallam, Edmonds, Everett, Grove, Lystair, Maytown, McMurray, Mukilteo, Norma, Orcas, Semiahmoo, Sinclair, Tacoma, and Swantown.

The Discovery Bay soils occur on uplands overlying cemented basalt conglomerate, and Olele and Ahl soils occur on uplands overlying basalt bedrock. The association occurs at elevations from near sea level to about 3,000 feet in a climatic zone having annual precipitation of 17 to 40 inches.

**Whidbey-Hoypus-Keysone-Swantown, with inclusions of Casey-Coveland, and organics, Soil Association (B04)**

The topography on which these soils occur is dominantly undulating, but ranges from gently undulating to steep, particularly on areas adjacent to drainages and salt water. The area consists of moderately well drained, cemented, gravelly, sandy basal till soils; somewhat excessively drained, deep, gravelly, sandy ablation, till soils; and poorly drained, clay loam and clay basin soils. Elevations range from nearly sea level to about 500 feet. Annual precipitation is about 18 to 30 inches.

Whidbey soils account for 55 percent of this association; Hoypus soils, 17 percent; Keystone soils, 6 percent; Swantown soils, 5 percent; Casey soils, 2 percent; organic soils, 2 percent; and the remaining 6 percent are Bozarth,

Coupeville, Ebeys, Hovde, Lummi, Norma, Pondilla, San Juan, and Townsend. All the soils of this association occupy 45 percent of the Whidbey Island soil survey area.

The nearly level, undulating, and rolling areas are used for pasture, hay, wood crop production, and urban developments.

**Rough Broken Land-Rough Stony Land (Cathcart Materials)-Cathcart-Alderwood-Indianola Soil Association (B14)**

Soils of this association are well drained to somewhat excessively drained. They occur on steep, hilly, and rolling topography on glaciated uplands with glacial materials overlying sandstone and argillite. At somewhat lower elevations, the glacial materials are strongly cemented basal till. Other areas are deep sandy soils.

Distribution of soils within the association is: Rough Mountainous, Rough Broken, and Rough Stony lands of Cathcart materials, 59 percent; Alderwood, 20 percent; Cathcart, 7 percent; Barneston, 2 percent; Puyallup, 3 percent; and Kitsap, 2 percent. These total 93 percent of the soil association. Making up the other 7 percent are: Bellingham, McMurray, Indianola, Issaquah, Everett, Mukilteo, Norma, Pilchuck, Puget, Sammamish, Snoqualmie, and Sultan.

The Cathcart soils occupy uplands underlain by bedrock, and the Alderwood soils occupy areas of basal till. The Barneston, Indianola, Everett, and Snoqualmie soils are formed in sandy and gravelly glacial outwash terraces. Soils of the Bellingham, and Norma series are formed in basin areas within the glacial terrace soils. Kitsap soils are formed from glacial lakes and marine sediments, and occur on undulating to rolling topography. Pilchuck, Puyallup, and Sultan soils are moderately well to excessively drained bottom land soils. Poorly drained bottom land soils are Puget, Sammamish, and Issaquah. Organic soils of the McMurray and Mukilteo series are formed in very poorly drained closed basins within the uplands and alluvial flood plains of the association.

**Puyallup-Sultan-Pilchuck-Puget Soil Association (B28)**

This soil association consists of somewhat excessively to poorly drained, nearly level bottom lands, and their adjacent nearly level to steep uplands. The bottom land soils are subject to periodic overbank flow flooding. The Puyallup and Pilchuck soils are excessively drained, sandy loams and sands respectively. Sultan soils are moderately well drained silt loams and light clay loams, and the Puget Soils are poorly drained clay loams and clay.

Soils in this association are: Puyallup, 49 percent; Sultan, 14 percent; Pilchuck, 12 percent; Puget, 7 percent; steep, broken lands adjacent to bottom land, 6 percent; McMurray peat in very poorly drained basins, 2 percent; Tacoma muck, which is very poorly drained organic soil on tidal

flats, 3 percent; and Snohomish, 2 percent. Other soils in the association occuring on 5 percent of the area are: Unclassified wet lands, Alderwood, Cathcart, Everett, Kitsap, Mukilteo peat, Norma, Sammamish, Woodinville (poorly drained bottom land soils), Snoqualmie, Barneston, Buckley, Enumclaw, Klaus, Hemmi, Newberg (a somewhat excessively drained bottom land soil), Orcas peat, Orting, Ragnar, Semiahmoo muck, Sinclair, Spanaway, Tanwax, Rockland, Greenwater, and Lynden.

Soils occur at elevations from near sea level to about 500 to 600 feet, in a climatic zone having annual precipitation of 30 to 60 inches. The adjacent uplands are nearly level to steep terraces, with moderately well drained Sinclair and Alderwood soils on cemented, gravelly, sandy, basal till plains; Kapowsin soils, which are moderately well drained on cemented, sandy clay basal till plains; Norma, McKenna, Mukilteo, Orcas, Semiahmoo, which occur in poorly drained and very poorly drained basins. Everett, Barneston, Greenwater, Lynden, Ragnar, Snoqualmie, and Spanaway soils are somewhat excessively drained soils which occur on gently sloping to rolling, deep, gravelly, and sandy ablation till plains. Buckley, Enumclaw, and Orting soils occur on gently sloping and somewhat poorly to poorly drained glacial mudflow plains.

**Dungeness-Skokomish-Pilchuck Soil Association (C18)**

This soil association consists of gently sloping, well, somewhat poorly, and somewhat excessively drained bottom land soils. Soil series which occur in this soil association are: Dungeness, 44 percent; Skokomish, 13 percent; Pilchuck, 11 percent; unclassified wet and steep lands, 10 percent; Puget, 7 percent; Mukilteo, 6 percent; and Tacoma, 5 percent. Glacial terrace soils of the Everett, Grove, and Shelton series occur on the remaining 4 percent of the area.

The Pilchuck series are deep, somewhat excessively drained, sandy soils adjacent to stream channels. The Dungeness series are deep, well drained, silty soils. The Skokomish series are somewhat poorly drained, heavy silty, and silty clay loam soils. The Puget series are poorly drained silty clay loam and silty clay soils, and the organic soils of the Mukilteo, Orcas, and Tacoma series are very poorly drained basins within the flood plains and tidal flat areas.

**Clallam-Elwha-Agnew Soil Association (C24)**

This soil association consists of moderately deep, moderately well drained basal till and glacial lacustrine soils on gently sloping to hilly topography.

Soil series which occur in this association are: Clallam, 35 percent; Elwha, 26 percent; Agnew, 6 percent; Everett, 6 percent; Bellingham, 3 percent;

Carlsborg, 3 percent; Sequim, 2 percent; Crescent, 1 percent; and Dick, 1 percent. Rough broken and rough stony lands on hilly and steep topography occur on 15 percent of the area. Other soils which occur on 2 percent of the area are: Dungeness, McMurray, Orcas, Pilchuck, Puget, and Semiahmoo.

The Clallam series are moderately deep, moderately well drained soils on cemented gravelly sandy loam basal till terraces. The Elwha series are moderately deep, moderately well drained soils on cemented sandy clay basal till terraces. The Agnew series are moderately deep, moderately well drained soils on glacial-lacustrine terraces. Soils of the Bellingham, McMurray, Semiahmoo, and Orcas series occur on poorly and very poorly drained basins of the basal till terraces. Soils of the Everett, Carlsborg, Sequim, and Dick series occur on deep ablation till terraces. Crescent series are alluvial fans and colluvial materials from steep mountainous areas of sandstone and shale.

**Edgewick-Nooksack-Salal Soil Association (C28)**

These are gently sloping, somewhat excessively drained, and well drained bottom land soils subject to periodic overbank flow flooding. Edgewick and Salal soils are formed in alluvium from micaceous rock (granites, granodiorities, and schists) of the adjacent mountain areas. The Edgewick soils occur adjacent to the streams, and Salal soils are high bottom lands subject to less frequent flooding. The Nooksack series are silty clay soils. The soils occur at elevations of 60 to 200 feet, in a climatic zone having annual precipitation of 60 to 90 inches.

Soils in this association are: Edgewick, 49 percent; Nooksack, 17 percent; Salal, 7 percent; Pilchuck, 1 percent; Puget, 1 percent; Puyallup, 1 percent; Mukilteo, 2 percent; McMurray, 2 percent; Snoqualmie, 3 percent; and rough broken land, 10 percent. Other soils in the association are: Issaquah, Norma, Ragnar, and Snohomish.

The Edgewick, Pilchuck, and Puyallup series are somewhat excessively drained alluvial soils. The Nooksack and Salal series are well drained; the Puget, Issaguah, and Snohomish series are poorly drained alluvial soils. The Mukilteo and McMurrary (Rifle) series are very poorly drained organic soils which occur in the bottom land closed basins and old stream channels. The Snoqualmie and Ragnar series are gravelly and sandy ablation till terraces soils and the Norma series occur in poorly drained basins on terraces

**Klaus-Ragnar Soil Association (C36)**

This soil association consists of undulation to steep topography on somewhat excessively drained, gravelly and sandy, ablation till terraces at elevations of 150 to 600 feet, in a climatic zone having 60 to 80 inches of annual precipitation. Soils of this association are: Klaus, 80 percent; Ragnar, 15 percent; Snoqualmie, 2 percent; Barneston, 2 percent; and rough mountainous land, 1 percent.

The Klaus series are formed in loose, gravelly sand and the Ragnar series are formed in sands with stratified sand and gravel substrata. Snoqualmie and Barneston series are deep, glacial outwash sands and gravels, rough mountainous areas are dominantly shallow soils on acid igneous rock.

**Buckley-Alderwood-Enumclaw Soil Association (D14)**

This soil association consists of shallow, level to steep, poorly drained, somewhat excessively drained, dense, gravelly, cobbly and stony glacial sandy clay mudflow, basal till, and ablation till soils, and their associated poorly drained and very poorly drained basins.

Soil series of this association are: Buckley, 33 percent; Alderwood, 23 percent; Enumclaw, 19 percent; rough stony, rough broken, and rough mountainous land, 7 percent; Buckley-Enumclaw complex, 3 percent; Bellingham, 2 percent; Sultan, 2 percent; and Everett, 1 percent. The other soil series which occupy 10 percent of the area are: Bellingham, Cathcart, Edgewick, Edmonds, Greenwater, Indianola, Kapowsin, Kitsap, McKenna, Mukilteo, Norma, Orcas, Orting, Oso, Pilchuck, Puyallup, Puyallup-Buckley materials, Semiahmoo, Tacoma, Tanwax, and Rockland.

Buckley, Enumclaw, and Orting soil series occur on nearly level and rolling, poorly to somewhat poorly drained glacial sandy clay and mudflow, and clay basal till plains, with Bellingham, Edmonds, Norma, and Semiahmoo series which occur in their poorly and very poorly drained basins. Alderwood series occur on dense, cemented gravelly, sandy loam basal till with undulating to steep topography, and Bellingham, Norma, and organic soils occur in their poorly drained and very poorly drained basins. The Kapowsin series occur on undulating and rolling sandy clay basal till terraces, and the Kitsap series occur on associated lacustrine terraces with Bellingham, McKenna, Norma and organic soils in their poorly drained and very poorly drained basins. The Everett, Barneston, Indianola, and Greenwater series occur on undulating to hilly, somewhat excessively drained, sandy and gravelly ablation till terraces. Areas of Pilchuck, Puyallup and Sultan soils occur on the associated bottom land. The rough mountainous, rough broken, and rough stony lands occur on the adjacent hilly and mountainous areas.

**Dungeness-Dick-Pilchuck Soil Association (D18)**

This soil association consists of well drained and somewhat excessively drained, gently sloping bottom lands and terrace soils.

The soil series which occur in this association are: Dungeness, 39 percent; Dick, 13 percent; Pilchuck, 10 percent; miscellaneous unclassified rough broken and wetlands, 13 percent; Puget, 7 percent; Bellingham, 5 percent;

Carlsborg, 3 percent; Agnew, 2 percent; Everett, 2 percent; Clallam, 1 percent; and Semiahmoo, 1 percent. Other miscellaneous soils make up the remaining 4 percent of this soil association.

The Dungeness series are deep, well drained bottom land soils, and the Pilchuck series are deep, somewhat excessively drained bottom land soils. The Carlsborg, Dick, and Everett series are deep, somewhat excessively drained ablation till soils. The Clallam series are moderately deep, moderately well drained basal till soils, and the Bellingham and Semiahmoo series occur in poorly drained basins of bottom lands and glacial terraces. The Agnew series occur on gently sloping to rolling glacial-lacustrine terraces.

**Chehalis-Greenwater-Semiahmoo-Nesika Soil Association (D28)**

This soil association is found on nearly level, well drained to very poorly drained bottom lands, associated with nearly level to very steep basal till terraces, ablation till terraces, and uplands.

Soils in the association are: Chehalis, 20 percent; Greenwater, 18 percent; Semiahmoo, 14 percent; Nesika, 10 percent; Newberg, 9 percent; Wilkeson, 6 percent; Pilchuck, 5 percent; Fitch, 3 percent; Everett, 2 percent; Klaber, 1 percent; Spanaway, 1 percent; and rough, broken, stony, and mountainous lands, 4 percent. Other soils of the association which occur on 7 percent of the area are: Maytown, McKenna, McMurray, Mukilteo, Norma, Reed, Schooley, Shuwah, Spanaway, Tumwater, Wapato, and Oso. The soils of this association occur at elevations of about 1,100 to 1,300 feet, in a climatic zone with an annual precipitation range of 40 to 60 inches.

**Spanaway-Everett-Fitch Soil Association (D36)**

This association consists of nearly level to hilly, somewhat excessively drained, deep, gravelly, sandy ablation till soils, most of which were formed under prairie vegetation.

Soil series in the association are: Spanaway, 60 percent; Everett, 12 percent; Fitch, 8 percent; Nisqually, 3 percent; Norma, 3 percent; Sultan, 3 percent; McKenna, 2 percent; rough stony, rough broken, and rough mountainous lands, 2 percent; Alderwood, 1 percent; and Indianola, 1 percent. Other soils included in the association which occur on 5 percent of the area are: Bellingham, Bow, Dupont, Cathcart, Chehalis, Edmonds, Everson, Giles, Kapowsin, Kitsap, Lynden, McKenna, McMurray, Mukilteo, National, Newber, Norma, Orcas, Oso, Pilchuck, Puget, Puyallup, Reed, Semiahmoo, Sinclair, Shuwah, Snohomish, Tanwax, Tenino, Tromp, Melborne, Wapato, and Wilkeson.

These soils occur on undulating to hilly, basal till and ablation till terraces and their associated poorly and very poorly drained basins and bottom land flood plains. Upland soils overlie basalt, sandstone, and shale bedrock. The

soils occur at elevations of 50 to 400 feet, in a climatic zone which has annual precipitation of 40 to 45 inches.

## Kapowsin-Everett-Alderwood Soil Association (E14)

This association consists of undulating to hilly, moderately deep to deep, moderately well, somewhat poorly, and somewhat excessively drained cemented basal sandy and sandy clay till soils, and their associated poorly drained basins and bottom lands.

Soils which occur in this association are: Kapowsin, 35 percent; Everett, 22 percent; Alderwood, 15 percent; rough stony and rough broken land, 8 percent; Kitsap, 2 percent; McKenna, 2 percent; with Barneston, Bellingham, Dupont, Norma, Semiahmoo, Spanaway, and Tenino each occurring on 1 percent of the area. Thirty-four other soil series occur on 9 percent of the area. These soils are: Bow, Chehalis, Edmonds, Enumclaw, Fitch, Indianola, Kopiah, Lynden, McMurray, Mukilteo, National, Newberg, Orting, Orcas, Pilchuck, Puget, Puyallup, Sinclair, Snohomish, Sultan, Tanwax, Tacoma, Waptao, Wilkeson, Cathcart, Delphi, Eld, Everson, Greenwater, Tromp, Tumwater, Nisqually, Sultan, and Maytown. Soils occur on terraces and bottom lands at elevations of 100 to 300 feet, in a climatic zone with annual precipitation of 35 to 50 inches.

## Pickett-Rockland-Roche Soil Association (E15)

These are well drained uplands overlying sandstone and graywacke or limestone bedrock at 12 to 60 inches or more, with 25 to 50 percent rocklands and rock outcrop areas. The soils occur on undulating to very steep topography in a mild, marine climate with precipitation of 20 to 30 inches and more, and they occur at elevations of sea level to 2,600 feet.

Soils in the association are: Pickett-rock outcrop complex, 85 percent; Rockland, 8 percent; and Roche, 3 percent. Other soils occurring on 4 percent of the association are: Bow, Coveland, Everett, Indianola-Roche complex; Norma, San Juan, and Semiahmoo.

Pickett-Rockland complex occurs on the uplands. Pickett silt loam soils are 12 to 60 inches deep and overlie sandstone or graywacke bedrock. Pickett soils occupy about 60 percent of the area and rock outcrop or Rocklands, 40 percent of the area. Roche soils occur on lowlying hills of undulating and rolling topography. These soils are formed in dense, stratified, sandy and clay basal till. Other soils of the association are described in the Roche-Bow-Coveland Soil Association (A15).

**Alderwood-Sinclair-Clallam Soil Association (F14)**

This soil association consists of moderately deep and shallow, moderately well drained, gravelly, sandy, cemented basal till soils on gently sloping to steep topography.

Soil series in this association are: Alderwood, 50 percent; Sinclair, 8 percent; Clallam, 6 percent; rough broken lands, 6 percent; Indianola, 5 percent; Kapowsin, 4 percent; Agnew, 2 percent; Everett, 2 percent; Harstine, 2 percent; and Cloquallum, McMurray, Swantown, and Whidbey, each 1 percent. The remaining 11 percent of the association area is occupied by the following soils series, which are grouped according to their slope, drainage class, character of soil formation, and topographic position:

Well drained, steep uplands—Olympic, Tebo, Cathcart, Discovery Bay.

Moderately well drained and somewhat poorly drained, gently sloping to steep basal till terrace soils—Bow, Bozarth, Clallam, Elwha, Hoodsport, Kapowsin, McCleary, Sinclair, Shelton, Swantown, Townsend, Whidbey, and Harstine.

Somewhat excessively and well drained, deep ablation till terrace soils—Carlsborg, Carstairs, Dick, Everett, Fitch, Giles, Grove, Indianola, Keystone, Lynden, Lystair, Nisqually, Ragnar, San Juan, Spanaway, and Hoypus.

Moderately well and somewhat poorly drained lacustrine (glacial lake) terrace soils—Agnew, Casey, Cloquallum, Kitsap, Nordby, and Saxton.

Poorly and very poorly drained terrace basins on nearly level topography—Bellingham, Dupont, Ebeys, Edmonds, Everson, McKenna, McMurray, Mukilteo, Orcas, and Tanwax.

Gently sloping bottom land soils—Belfast, Chehalis, Eld, Hovde, Juno, Koch, Lummi, Maytown, Norma, Nuby, Puget, Puyallup, Reed, Snohomish, Sultan, Tacoma, and Wapato.

Sloping, moderately well, and imperfectly drained outwash terraces and alluvial fans from shale and basalt—Galvin and Waddell.

The Alderwood, Clallam, Sinclair, Kapowsin, Harstine, Swantown, and Whidbey series are basal till soils on cemented gravelly, sandy, and gravelly sandy clay substrata. Generally, the rough broken lands are similar soil materials on slopes in excess of 30 percent. Indianola and Everett series are ablation till outwash sands and gravels. The Cloquallum series are glacial lake terrace soils. The basin soils listed above occur on poorly drained areas within the glacial terraces, and the bottom land soils occur adjacent to drainageways.

**Nisqually-Giles-Tumwater Soil Association (G36)**

This association of soils occurs on nearly level to rolling, somewhat excessively, and well drained ablation till outwash plains of deep sands and gravel. The association includes moderately deep basal till soils, with cemented gravelly sandy substrata, and their associated poorly and very poorly drained basins.

Soils included in the association are: Nisqually, 28 percent; Giles, 22 percent; Tumwater, 17 percent; Alderwood, 8 percent; Mukilteo, 4 percent; Lynden, 3 percent; Everson, 2 percent; Tenino, 2 percent; rough stony, rough broken, and rough mountainous lands, 2 percent; Fitch, 1 percent; Semiahmoo, 1 percent; and Spanaway, 1 percent. Other soils which occur on 9 percent of the association are: Bellingham, Edmonds, Indianola, McKenna, McMurray, Melbourne, Norma, Olympic, Orcas, Puyallup, and Tromp.

Melborne and Olympic series are moderately deep to deep upland soils on shale and basalt bedrock, respectively. Alderwood and Tenino series occur on undulating to hilly, basal till plains with cemented gravelly sandy substrata. Everett, Fitch, Indianola, Lynden, Nisqually, Spanaway, and the Giles series occur on nearly level to hilly ablation till sandy, gravelly, and silty outwash plains. The Bellingham, Everson, McKenna, Norma, and Tromp series occur on nearly level, poorly drained basins. The organic soils, which are McMurray, Mukilteo, Orcas, and Semiahmoo, occur in very poorly drained closed basins. The Puyallup series are somewhat excessively drained bottom land soils. Soils of this association occur at elevations from near sea level to near 1,000 feet, in a climatic zone having annual precipitation of 45 to 60 inches.

**Hoodsport-Shelton-Grove Soil Association (H14)**

This soil association consists of undulating to steep, moderately well drained, moderately deep basal till soils, somewhat excessively drained ablation till soils, and shallow to moderately deep upland soils on bedrock.

Soil series which occur in this soil association are: Hoodsport, 39 percent; Grove, 19 percent; Shelton, 19 percent; Cloquallum, 6 percent; Swantown, 4 percent; Tebo, 2 percent; Olele, 2 percent; and rough broken land, 1 percent. Thirty-four soil series occur on the remaining 8 percent of the area. These soil series are listed by their slope, drainage class, character of soil formation, and topographic position as follows:

Well drained, steep upland soils developed on bedrock—Ahl.

Gently sloping to rolling outwash terraces and alluvial fans from upland soil areas—Waddell.

Moderately well drained, gently sloping to steep basal till terraces soils—Alderwood, Delphi, Sinclair.

Somewhat excessively and well drained, deep ablation till terrace soils—Cartairs, Ebeys, Everett, Indianola, and Lystair.

Moderately well and somewhat poorly drained lacustrine (glacial lake) terrace soils—Kitsap, Nordby.

Poorly and very poorly drained terrace basins on nearly level topography—Bellingham, Edmonds, McKenna, McMurray, Norma, Orcas, Tanwax.

Gently sloping, poorly to well drained bottom lands—Belfast, Dungeness, Eld, Juno, Koch, Lummi, Maytown, Nuby, Pilchuck, Puget, Reed, Skokomish, Tacoma, Wapato.

The Hoodsport, Shelton, and Swantown series are moderately well drained and occur on gently sloping to steep cemented basal till terraces.

The Grove series are somewhat excessively drained, gravelly sandy ablation till soils on gently sloping to steep topography.

Cloquallum soils occur on gently sloping to steep, moderately well drained lacustrine (glacial lake) terraces.

Tebo and Olele series are shallow to moderately deep upland soils formed on bedrock.

Rough broken lands are steep, rocky areas on soil materials similar to the adjacent land areas.

## SOIL ASSOCIATION MAP LEGENDS

The principal soils grouped by the colors and numbers shown on the Generalized Soils Map, Figure 3 are listed below:

**Red**. Gently sloping to steep, moderately deep, moderately well, and somewhat poorly drained gravelly sandy, gravelly silty clay loam, and gravelly clay glacial basal till soils.

A02—Squalicum-Whatcom-Kickerville-Barnhardt soil association
A03—Whatcom-Labounty-Cagey-McKenna-Norma soil association
A14—Alderwood-Everett-Kitsap soil association
A15—Roche-Bow-Coveland soil association
B14—Rough Broken Land-Rough Stony Land (Cathcart Materials)
Cathcart-Alderwood-Indianola soil association
C24—Clallam-Elwha-Agnes soil association
D14—Buckley-Alderwood-Enumclaw soil association
E14—Kapowsin-Everett-Alderwood soil association
F14—Alerwood-Sinclair-Clallam soil association
H14—Hoodsport-Shelton-Grove soil association

**Yellow.** Gently sloping, deep to shallow, somewhat excessively drained bottom land and organic basin soils subject to flooding.

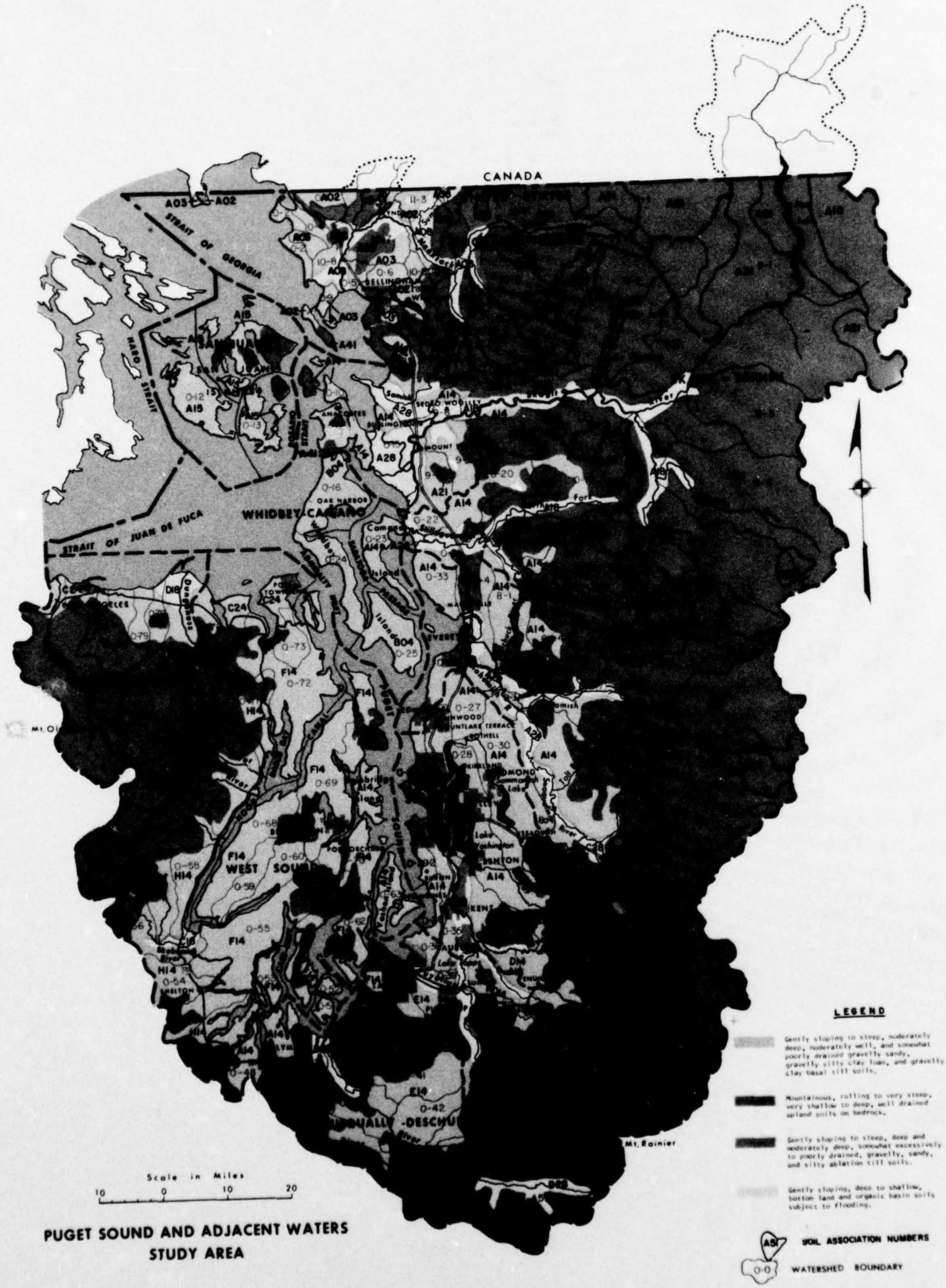
A08—Puyallup-Puget-Nooksack-Pilchuck
A18—Puyallup-Pilchuck-Puget-Riverwash
A28—Puget-Sumas-Snohomish-Sultan
B28—Puyallup-Sultan-Pilchuck-Puget
C18—Dungeness-Skokomish-Pilchuck
C28—Edgewick-Nooksack-Salal
D18—Dungeness-Dick-Pilchuck
D28—Chehalis-Greenwater-Semiahmoo-Nesika

**Green.** Gently sloping to steep, deep and moderately deep, somewhat excessively to poorly drained, gravelly, sandy, and silty glacial ablation till soils.

A05—Lynden-Custer-Giles
A09—Barneston-Oso-Smith Creek
A23—Custer-Lynden-Norma
A36—Everett-Barneston-Indianola-Alderwood
C36—Klaus-Ragnar
D36—Spanaway-Everett-Fitch
G36—Nisqually-Giles-Tumwater

**Purple.** Mountainous, rolling to very steep, very shallow to deep, well drained uplands soils on bedrock.

A04—Pickett-Rockland
A10—Rough Mountainous
A20—Rough Mountainous Lands-Crescent-Sandstone Soil Materials
A21—Rough Mountainous-McLeod-Marblemount
A31—Rough Mountainous Land-Heisler-Thornwood (Schist, Argillite and Gneiss)
A41—Fidalgo-Rockland
A51—Rough Mountainous-Wilkeson Soil Materials
A61—Rough Mountainous Lands—Olympic Soil Materials
A71—Rough Mountainous Lands-Melbourne Soil Materials
A81—Rough Mountainous Lands-Tebo-Ahl
A91—Discovery Bay-Olele-Ahl
E15—Pickett-Rockland-Roche




**PUGET SOUND AND ADJACENT WATERS STUDY AREA**

**Figure 3.** **Generalized Soils Map**

# GENERAL PROPERTIES OF SOILS

## PROPERTIES OF SOILS BY SOIL SERIES

The soil series and land types in the Puget Sound Area are listed alphabetically in the first column of Table 6. The second column indicates the part of the landscape in the Puget Sound Area that each series or land type occupies. The third and fourth columns, respectively, list the surface textures and the water intake rates. In the fifth through the eighth columns are the texture, consistence,[1] permeability, and the reaction of the subsoil. Also listed in the ninth through the twelfth columns are the texture, consistence, permeability, and reaction of the substrata. The thirteenth column gives the depth of root penetration and the last column shows the water-holding capacity of the soil.

The properties listed in this table are the basic information that was used to make interpretive groupings of the soils in the Puget Sound Area.

The reader is referred to the Glossary for explanations of the soil properties shown on this table.

[1] Soil consistence: Comprises the attributes of soil material that are expressed by the degree and kind of cohesion and adhesion, or by the resistance to deformation or rupture (Soil Conservation Manual, USDA Technical Publication No. 48).

Table 6. Properties of soils in Puget Sound Area. 1/

| Soil Series or Land Types | Topographic Position | Surface Soils | | Subsoils | | | | Substrata | | | | Depth of Root Penetration | Water Holding Capacity |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Textures | Water Intake Rates | Textures | Consistence | Permeability | Reaction pH | Textures and/or Parent Material | Consistence | Permeability | Reaction pH | | |
| | | | (in/hr) | | | (in/hr) | | | | (in/hr) | | (inches) | (inches) |
| Active dunes | Terraces and beaches | Sands | 5.0-10.0 | Sands | Loose | 5.0-10.0 | 6.6-7.3 | Sands | Loose | 5.0-10.0 | 6.6-7.3 | 20.0-36.0 | 3.0-6.0 |
| Agnew | Upland terrace | Fine sandy loam, sandy loam, loam, silty clay loam | 0.2-0.5 | Silty clay loam | Friable and plastic | 0.05-0.2 | 6.6-7.3 | Sands, silts and clays | Hard, friable and plastic | 0.05-0.2 | 6.6-7.3 | 20.0-36.0 | 6.0-9.0 |
| Ahl | Upland terrace | Very gravelly silt loam | | Very gravelly silt loam | Firm | 0.8-2.5 | 6.1-6.5 | Basalt bedrock | Hard | Less than 0.05 | --- | 12.0-20.0 | |
| Alderwood 2/ | Upland terrace | Loam, gravelly sandy loam, gravelly loam, silt loam, fine sandy loam, loamy sand | 0.2-0.75 | Gravelly sandy loam | Very friable | 0.8-2.5 | 5.6-6.0 | Sandy and gravelly glacial basal till | Firm. Hard when dry. Cemented | 0.05-0.2 | 5.6-6.5 | 20.0-36.0 | 3.3-6.0 |
| Alluvial soils, undifferentiated | Alluvial flood plains | Undifferentiated. Gravels, sands, sandy loams, silt loams or clay | 0.05-10.0 | Variable gravels, sands, silts and clays | Loose to firm and plastic | Variable 0.05-10.0 | 5.6-7.3 | Variable gravels, sands, silts and clays | Variable Loose to firm | Variable 0.05-10.0 | 6.1-7.3 | 20.0-36.0 | 3.0-12.0 |
| Astoria | Upland | Silt loam | 0.2-0.5 | Silty clay loam | Firm and plastic | 0.05-0.2 | 5.1-5.5 | Shale or sandstone | Hard | 0.05-0.2 | 5.1-5.5 | 20.0 60.0 | 9.0-12.0 |



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Table 6. Properties of soils in Puget Sound Area. 1/ (con.)

| Soil Series or Land Types | Topographic Position | Surface Soils | | Subsoils | | | | Substrata | | | | Depth of Root Penetration | Water Holding Capacity |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Textures | Water Intake Rates | Textures | Consistence | Permeability | Reaction pH | Textures and/or Parent Material | Consistence | Permeability | Reaction pH | | |
| | | | (in/hr) | | | (in/hr) | | | | (in/hr) | | (inches) | (inches) |
| Barneston | Upland terraces | Silt loam, stony silt loam gravelly sandy loam, gravelly fine sandy loam and gravelly loamy sand | 0.4-0.75 | Silt loam, gravelly silt loam or gravelly sands with clay coatings | Friable to very friable and loose | 2.5-5.0 | 5.6-6.0 | Sands and gravelly sands. Glacial outwash. | Loose and porous | 5.0-10.0 | 6.6-7.3 | 20.0-36.0 | 4.0-6.0 |
| Barnhardt | Upland terraces | Gravelly silt loam and gravelly sandy loam | 0.2-0.5 | Gravel and sand | Loose | 2.5-5.0 | 5.6-6.0 | Cemented gravel and sand glacial till at 6 to 8 feet. | Firm and hard. Cemented | 5.0-10.0 over 10 feet 0.05-0.2 | 6.6-7.3 | 20.0-36.0 | 4.5-8.0 |
| Belfast | Bottomlands | Silt loam, fine sandy loam and sandy loam | 0.2-0.5 | Silt loam or loam | Friable | 0.2-0.8 | 5.6-6.5 | Silt loam, loam or sandy loams | Friable | 0.2-0.8 | 5.6-6.5 | 36.0-60.0 | 6.0-7.4 |
| Bellingham 2/ | Terrace basins | Silty clay loam, clay loam, silty clay, clay, silt loam, loam, and fine sandy loam | 0.1-0.3 | Silty clay loam, silty clay or clay | Firm, sticky and plastic | 0.05-0.2 | 5.6-7.3 | Clay and sandy clay | Firm, sticky and plastic | Less than 0.05 | 6.6-7.3 | 12.0-30.0 | 5.5-6.5 |
| Bow | Upland terraces | Silt loam, gravelly silt loam, loam, grav. loam, clay loam, silty clay loam and stony silt loam | 0.2-0.5 | Loam and fine sandy loam | Firm, sticky and slightly plastic | 0.05-0.2 | 6.1-6.5 | Silty clay or clay glacial till | Hard, sticky and plastic | Less than 0.05 | 6.6-7.3 | 12.0-36.0 | 4.3-6.0 |

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| Soil Series or Land Types | Topographic Position | Surface Soils | | Subsoils | | | | Substrata | | | | Depth of Root Penetration | Water Holding Capacity |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Textures | Water Intake Rates | Textures | Consistence | Permeability | Reaction pH | Textures and/or Parent Material | Consistence | Permeability | Reaction pH | | |
| | | | (in/hr) | | | (in/hr) | | | | (in/hr) | | (inches) | (inches) |
| Bozarth | Upland terraces | Fine sandy loam | 0.2-0.5 | Fine sandy loam | Firm | 0.8-2.5 | 5.6-6.0 | Gravelly sandy glacial basal till | Hard, strongly cemented | 0.05-0.2 | 6.6-7.3 | 20.0-36.0 | 3.0 |
| Buckley | Upland terrace | Loam, silt loam and clay loam | 0.10-0.3 | Gritty clay loam or gritty silty clay loam | Friable | 0.8-2.5 | 5.6-6.0 | Very gravelly clay loam, glacial mudflow | Hard, strongly cemented | 0.05-0.2 | 5.6-6.0 | 20.0-30.0 | 4.5-6.0 |
| Cagey | Upland terrace | Gravelly sandy loam, gravelly fine sandy loam, sandy loam, silt loam and gravelly loam | 0.2-0.75 | Gravelly sand | Friable | 2.5-5.0 | 5.6-6.0 | Gravelly clay loam, gravelly silty clay or gravelly sandy loam Glacial basal till | Hard, strongly cemented | Less than 0.05 | 7.3-7.6 | 30.0-48.0 | 3.3-6.0 |
| Camas 2/ | Low terraces | Clay loam and gravelly loam | 0.2-0.4 | Clay loam to gravelly clay loam | Firm and plastic | 0.2-0.8 | 6.1-6.5 | Gravelly and sandy alluvium | Loose | 5.0-10.0 | 6.1-6.5 | 20.0-30.0 | 3.7-5.3 |
| Carbondale | Terrace and bottom-land basins | Muck | 0.2-0.4 | Peat, woody | Fibrous | 0.05-2.5 | 5.1-5.5 | Sedimentary peat, sand, silt or clay | Hard when dry | Less than 0.05 | 5.1-5.5 | 12.0-36.0 | 4.4-12.0 |
| Carlsborg | Upland terrace | Gravelly loam and gravelly sandy loam | 0.4-0.75 | Very gravelly sandy loam or very gravelly loam | Very friable | 2.5-5.0 | 6.6-7.3 | Very gravelly sandy loam, river terraces | Loose | 2.5-5.0 | 6.6-7.3 | 20.0-36.0 | 5.0-6.0 |
| Carstairs | Upland glacial terrace | Gravelly loam | 0.3-0.75 | Gravelly sandy loam | Very friable | 5.0-10.0 | 5.1-5.5 | Sandy gravel, cobbles and stones | Loose | 5.0-10.0 | 5.1-5.5 | Moderately deep | 5.0-6.0 |

Table 6. Properties of soils in Puget Sound Area. 1/ (con.)

| Soil Series or Land Types | Topographic Position | Surface Soils | | Subsoils | | | | Substrata | | | | Depth of Root Penetration | Water Holding Capacity |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Textures | Water Intake Rates | Textures | Consistence | Permeability | Reaction pK | Textures and/or Parent Material | Consistence | Permeability | Reaction pH | | |
| | | | (in/hr) | | | (in/hr) | | | | (in/hr) | | (inches) | (inches) |
| Casey | Upland terraces | Loam, fine sandy loam, silt loam | 0.2-0.5 | Sandy loam or loam on clay | Hard | Less than 0.05 | 5.1-5.5 | Clay or silty clay loam on cemented glacial till | Hard | Less than 0.05 | 5.1-5.5 | 8.0-20.0 | 5.0-7.0 |
| Cathcart 2/ | Upland | Loam, gravelly loam, gravelly silt loam, stony loam, fine sandy loam, clay loam | 0.2-0.5 | Gritty loam | Hard | 0.8-2.5 | 5.6-6.0 | Sandy loam, grading to sandstone at about 4 feet | Hard | 0.05-0.2 | 5.6-6.0 | 36.0-60.0 | 6.0-10.0 |
| Chehalis 2/ | Alluvial flood plain | Loam, silt loam and silty clay loam | 0.1-0.4 | Silt loam and silty clay loam | Very hard, sticky and plastic | 0.8-2.5 | 6.1-6.5 | Silty clay loam | Hard sticky and plastic | 0.8-2.5 | 6.1-6.5 | 40.0-60.0 | 6.0-11.0 |
| Chimacum | Upland glacial terrace | Gravelly sandy loam, gravelly loam, very gravelly loamy sand | 0.5-1.1 | Gravelly sands | Loose | 5.0-10.0 | 6.1-6.5 | Very gravelly sand | Loose | 5.0-10.0 | 6.1-6.5 | 20.0-30.0 | 5.0-6.0 |
| Cinebar | Upland | Silt loam | 0.2-0.5 | Silt loam | Firm, plastic | 0.8-2.5 | 5.6-6.0 | Silt loam | Firm, plastic | 0.05-0.2 | 5.6-6.0 | 36.0-60.0 | 10.0-12.0 |
| Cispus | Upland | Pumicy sandy loam | 0.5-1.1 | Pumicy sandy loam | Firm | 2.5-5.0 | 5.6-6.0 | Silt loam | Firm | 0.2-0.8 | 5.6-6.0 | 20.0-36.0 | 4.0-5.0 |
| Clackamas | Old terrace | Silty clay loam | 0.1-0.3 | Clay | Hard, very plastic | Less than 0.05 | 5.6-6.0 | Gravelly clay | Hard, very plastic | 0.05-0.2 | 5.6-6.0 | 12.0-20.0 | 4.0-5.0 |

Table 6. Properties of soils in Puget Sound Area. 1/ (con.)

| Soil Series or Land Types | Topographic Position | Surface Soils | | Subsoils | | | | Substrata | | | | Depth of Root Penetration | Water Holding Capacity |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Textures | Water Intake Rates | Textures | Consistence | Permeability | Reaction pH | Textures and/or Parent Material | Consistence | Permeability | Reaction pH | | |
| | | | (in/hr) | | | (in/hr) | | | | (in/hr) | | (inches) | (inches) |
| Clallam | Upland terrace | Loam, gravelly loam, gravelly sandy loam | 0.2-0.75 | Loam and gravelly loam | Very hard | 0.2-0.8 | 5.6-6.0 | Gravelly loam glacial basal till | Very hard | Less than 0.05 | 5.6-6.0 | 20.0-30.0 | 3.0-5.0 |
| Clipper | Alluvial bottomland | Silty clay loam | 0.1-0.3 | Gravelly loam | Very hard | Less than 0.05 | 6.1-6.5 | Sand and gravel alluvium | Compact | 0.05-0.2 | 5.6-6.0 | 12.0-20.0 | 4.0-6.0 |
| Cloquallum | Upland | Silt loam, loam and silty clay loam | 0.1-0.3 | Silty clay loam | Firm, sticky and plastic | 0.2-0.8 | 5.6-6.0 | Silty clay loam. Glacial cemented till and lacustrine | Compact and hard | 0.05-0.2 | 5.6-6.0 | 24.0-40.0 | 6.0-7.0 |
| Coastal beach | Beach areas | Sands and gravelly, stony or cobbly sands | 0.5-1.1 | Sands and gravelly, stony or cobbly sands | Loose | 5.0-10.0 | 5.6-6.0 | Sands and gravelly, stony or cobbly sands | Loose | 5.0-10.0 | 5.6-6.0 | 12.0-20.0 | 3.0-4.0 |
| Cokedale | Alluvial flood plain | Silty clay loam, silt loam, loam, and sandy loam | 0.1- | Silts and fine sands | Firm, non-sticky | 0.05-0.2 | 5.6-6.0 | Sand, fine sand, fine sandy loam, or clay loam. Stratified alluvium. | Loose to firm | Variable 0.05-2.5 | 5.6-6.0 | 20.0-36.0 | 8.0-10.0 |
| Corkindale | Upland | Loam | 0.4-0.75 | Gravelly | Friable | 0.8-2.5 | 5.1-5.5 | Gravelly sand Glacial outwash | Loose | 5.0-10.0 | 5.1-5.5 | 20.0-36.0 | 4.0-5.5 |

Table 6. Properties of soils in Puget Sound Area. 1/ (con.)

| Soil Series or Land Types | Topographic Position | Surface Soils: Textures | Surface Soils: Water Intake Rates (in/hr) | Subsoils: Textures | Subsoils: Consistence | Subsoils: Permeability (in/hr) | Subsoils: Reaction pH | Substrata: Textures and/or Parent Material | Substrata: Consistence | Substrata: Permeability (in/hr) | Substrata: Reaction pH | Depth of Root Penetration (inches) | Water Holding Capacity (inches) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Colvos | Upland terrace | Fine sandy loam | 0.5-1.1 | Fine sandy loam | Firm, friable | 0.8-2.5 | 6.1-6.5 | Fine sandy loam. Glacial outwash terrace | Hard. Slightly iron cemented | 0.05-0.2 | 6.1-6.5 | 20.0-40.0 | 4.0-5.0 |
| Coveland | Upland | Gravelly loam, gravelly silt loam, silt loam, or stony silt loam | 0.2-0.5 | Gravelly sandy loam, or sandy clay loam | Hard slightly sticky to sticky and plastic | 0.05-0.2 | 6.1-6.5 | Clay loam, sandy clay or clay | Extremely hard. Very sticky and very plastic | Less than 0.05 | 6.6-7.3 | 20.0-30.0 | 5.0-7.0 |
| Coupeville | Upland terrace | Loam, silt loam | 0.1-0.3 | Sandy loam | Hard | 0.2-0.8 | 5.6-6.0 | Clay. Marine and glacial lake sediments | Very hard, plastic | 0.05-0.2 | 5.1-5.5 | 20.0 36.0 | 6.0-7.0 |
| Crescent | Upland | Gravelly loam | 0.2-0.5 | Gravelly and rocky loam | Friable | 2.5-5.0 | 5.6-6.0 | Rocky loam | Friable | 5.0-10.0 | 5.6-6.0 | Deep | 3.0-4.0 |
| Custer | Upland terrace | Sandy loam, fine sandy loam, silt loam | 0.4- | Fine sandy loam, iron cemented | Firm, plastic | 0.05-0.2 | 5.1-5.5 | Loamy sand. Glacial outwash. | Firm | 0.05-0.2 | 5.1-5.5 | 20.0-30.0 | 3.5-5.0 |
| Dabob | Upland terrace | Very gravelly sandy loam | 0.5-1.1 | Very gravelly sandy loam | Friable | 2.5-5.0 | 6.1-6.5 | Gravelly sandy loam Glacial basal till | Strongly cemented | 0.05-0.2 | 5.6-6.0 | Moderately shallow | 4.0-5.0 |
| Delphi 2/ | Upland terrace | Gravelly loam | 0.2-0.5 | Gravelly clay loam | Firm, plastic | 0.2-0.8 | 5.6-6.0 | Gravelly sandy clay glacial basal till | Hard cemented | 0.05-0.2 | 5.6-6.0 | 20.0-36.0 | 4.8-11.0 |

Table 6. Properties of soils in Puget Sound Area. 1/ (con.)

| Soil Series or Land Types | Topographic Position | Surface Soils | | Subsoils | | | | Substrata | | | | Depth of Root Penetration | Water Holding Capacity |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Textures | Water Intake Rates | Textures | Consistence | Permeability | Reaction pH | Textures and/or Parent Material | Consistence | Permeability | Reaction pH | | |
| | | | (in/hr) | | | (in/hr) | | | | (in/hr) | | (inches) | (inches) |
| Dick | Upland terrace | Loamy fine sand and loamy sand | 0.4-1.1 | Loamy fine sand and loamy sand | Very friable | 5.0-10.0 | 6.1-6.5 | Loamy fine sand and loamy sand. Glacial outwash | Loose | 5.0-10.0 | 6.1-6.5 | 20.0-40.0 | 4.0-5.0 |
| Discovery Bay | Upland | Gravelly sandy loam, very gravelly sandy loam | 0.4- | Sand, gravel and cobbles | Loose | 2.5-5.0 | 5.6-6.0 | Silica cemented basaltic old alluvium | Very hard | 0.8-2.5 | 5.6-6.0 | 20.0-36.0 | 3.0-4.0 |
| Dungeness | Alluvial bottomland | Fine sandy loam, silt loam, loam | 0.2-0.5 | Silt loam and fine sandy loam | Firm | 0.8-2.5 | 5.6-6.0 | Sands and fine sands | Friable to loose | 5.0-10.0 | 5.6-6.0 | 40.0-60.0 | 9.0-11.0 |
| Dupont | Basins | Muck | 0.1-3.5 | Silty diatomite or ash | Soft, friable | 0.2-0.8 | 5.1-5.5 | Sedimentary peat | Very soft. Very hard when dry | 0.05-0.2 | 5.1-5.5 | 12.0-20.0 | 10.0-12.0 |
| Ebeys | Upland terrace | Sandy loam | 0.3-0.5 | Sandy loam | Firm, hard | 0.8-2.5 | 6.1-6.5 | Coarse sands | Firm | 5.0-10.0 | 6.6-7.3 | 20.0-36.0 | 5.7-7.0 |
| Edgewick | Allu- | Fine sandy loam, very fine sandy loam, silt loam and sands | 0.4-1.1 | Micaceous fine sandy loam | Soft | 0.8-2.5 | 6.1-6.5 | Stratified micaceous sands | Loose | 5.0-10.0 | 6.1-6.5 | 20.0 60.0 | 3.2-8.0 |

Table 6. Properties of soils in Puget Sound Area. 1/ (con.)

| Soil Series or Land Types | Topographic Position | Surface Soils | | Subsoils | | | | Substrata | | | | Depth of Root Penetration | Water Holding Capacity |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Textures | Water Intake Rates | Textures | Consistence | Permeability | Reaction pH | Textures and/or Parent Material | Consistence | Permeability | Reaction pH | | |
| | | | (in/hr) | | | (in/hr) | | | | (in/hr) | | (inches) | (inches) |
| Edmonds | Upland basins | Sandy loam, fine sandy loam, loam, silt loam, loamy sand | 0.2-0.75 | Loamy sand, iron cemented | Firm to hard | Variable 0.05-5.0 | 5.1-6.0 | Sand over glacial basal till | Loose to hard cemented | 0.05-0.2 | 5.1-6.0 | 12.0-20.0 | 3.2-6.0 |
| Eld | Alluvial flood plains | Clay loam, silt loam, loam and gravelly loam | 0.10-0.5 | Clay loam or loam | Firm | 0.2-0.8 | 6.1-6.5 | Gravelly sandy loam and gravelly sands | Firm | 0.2-0.8 | 6.1-6.5 | 20.0-48.0 | 8.0-10.0 |
| Elwha | Upland terrace | Loam | 0.2-0.5 | Sandy clay | Hard, sticky, plastic | 0.05-0.2 | 5.6-6.0 | Sandy clay glacial basal till, gravelly and stony | Very hard, sticky and plastic | Less than 0.05 | 5.6-6.0 | 20.0-36.0 | 6.0-7.0 |
| Enumclaw | Upland terrace | Loam, fine sandy loam, gravelly sandy loam | 0.2-0.5 | Gritty loam and gritty clay loam | Hard | 0.2-0.8 | 6.1-6.5 | Gravelly clay glacial basal till or mudflow | Very hard, sticky and plastic | 0.05-0.2 | 6.1-6.5 | 20.0-48.0 | 3.0-5.0 |
| Everett 2/ | Upland terrace | Gravelly sandy loam, cobbly sandy loam, stony sandy loam, gravelly loamy sand, stony loamy sand, loam. | 0.4-1.1 | Gravelly and very gravelly loamy sands. | Loose | 5.0-10.0 | 5.6-6.0 | Gravel and sand. Ablation till. | Loose | 5.0-10.0 | 5.6-6.0 | 20.0-48.0 | 4.0-6.0 |
| Everson 2/ | Upland basins | Silt loam, clay loam, fine sandy loam | Less than 0.25 | Sandy clay or clay | Hard, very plastic | less than 0.05 | 5.1-5.5 | Sands | Loose | 0.2-0.8 | 5.6-6.0 | 12.0-20.0 | 4.5-6.0 |

Table 6. Properties of soils in Puget Sound Area. 1/ (con.)

| Soil Series or Land Types | Topographic Position | Surface Soils | | Subsoils | | | | Substrata | | | | Depth of Root Penetration | Water Holding Capacity |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Textures | Water Intake Rates | Textures | Consistence | Permeability | Reaction pH | Textures and/or Parent Material | Consistence | Permeability | Reaction pH | | |
| | | | (in/hr) | | | (in/hr) | | | | (in/hr) | | (inches) | (inches) |
| Fidalgo | Upland | Rocky loam | 0.25- | Rocky sandy loam or rocky loam | Firm | 0.8-2.5 | 5.1-5.5 | Serpentine bedrock | Very hard | Less than 0.05 | --- | 24.0 | 3.3 |
| Fitch 2/ | Upland | Gravelly | More than 0.5 | Gravelly loamy sand | Loose | 5.0-10.0 | 5.6-6.0 | Very grav. & cobbly sands | Loose | 5.0-10.0 | 5.6-6.0 | Over 40.0 | 5.0 |
| Giles 2/ | Upland | Silt loam, loam, fine sandy loam | 0.3-0.5 | Silt loam and silty clay loam | Firm | 0.2-0.8 | 5.6-6.0 | Fine sands, sands or grav. sands | Compact | 0.8-2.5 | 5.6-6.0 | Over 40.0 | 4.8-8.0 |
| Gilligan | Upland terrace | Gravelly loam, loam, silt loam | 0.3-0.5 | Micaceous silt loam | Firm | 0.2-0.8 | 5.1-5.5 | Micaceous sandy loam | Loose | 0.8-2.5 | 6.1-6.5 | 36.0-48.0 | 8.0 |
| Gravel Pits | Upland terrace | Gravel and sand | Over 10.0 | Gravel and sand | Loose | Over 10.0 | --- | Gravel and sand | Loose | Over 10.0 | --- | --- | 3.0 |
| Greenwater 2/ | Upland terrace | Loamy sands, sand and sandy loam | Over 0.55 | Loamy sand | Firm | 5.0-10.0 | 5.1-5.5 | Coarse sands | Loose | 5.0-10.0 | 5.6-6.0 | 40.0-48.0 | 4.0 |
| Greenwood 2/ | Closed basins | Sphagnum peat | Over 0.55 | Sphagnum peat | Fibrous | 0.8-2.5 | 4.5-5.0 | Sedimentary peat. Silty | Very soft | 0.8-2.5 | 4.5-5.0 | 12.0- or less | 12.0 + |
| Grove 2/ | Upland terrace | Grav. sandy loam, grav. loam, cobbly loam, stony sandy loam, very grav. sandy loam | 0.3 to more than 0.5 | Gravelly sandy loam, gravelly loam | Loose | 2.5-5.0 | 5.1-5.5 | Gravel and coarse sand glacial ablation till. Manganese coated | Loose | 5.0-10.0 | 5.6-6.0 | 30.0-36.0 | 3.8-5.5 |
| Hale | Upland terrace | Silt loam | 0.25-0.5 | Sands or grav. sands | Loose | 2.5-5.0 | 5.6-6.0 | Clay glacial basal till | Very hard | Less than 0.05 | 6.6-7.3 | 48.0 | 6.4-8.6 |

Table 6. Properties of soils in Puget Sound Area. 1/ (con.)

| Soil Series or Land Types | Topographic Position | Surface Soils: Textures | Surface Soils: Water Intake Rates (in/hr) | Subsoils: Textures | Subsoils: Consistence | Subsoils: Permeability (in/hr) | Subsoils: Reaction pH | Substrata: Textures and/or Parent Material | Substrata: Consistence | Substrata: Permeability (in/hr) | Substrata: Reaction pH | Depth of Root Penetration (inches) | Water Holding Capacity (inches) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Harstine | Upland terrace | Gravelly sandy loam | 0.3-0.5 | Gravelly sandy loam to gravelly fine sandy loam | Friable to loose | 0.8-2.5 | 5.1-5.5 | Gravelly sandy loam glacial basal till | Hard to weakly cemented | 0.05-0.2 | 5.1-5.5 | 36.0-48.0 | 4.5-6.0 |
| Heisler | Upland | Gravelly loam, shaly loam, stony loam | 0.25-0.5 | Shaly loam | Friable | 0.2-0.8 | 5.6-6.0 | Shaly argillite or schist. Bedrock at about 80" | Hard | 0.05-0.2 | 6.1-6.5 | 48.0-60.0 | 8.5 |
| Hemmi | Upland terrace | Silt loam | 0.25-5.0 | Clay and sandy clay | Very hard, plastic | Less than 0.05 | 5.6-6.0 | Sands, glacial outwash | Loose | 2.5-5.0 | 6.1-6.5 | 12.0-20.0 | 4.0-5.0 |
| Hoodsport | Upland terrace | Gravelly sandy loam, stony sandy loam, very gravelly sandy loam | 0.5-1.0 | Gravelly sandy loam, stony sandy loam, very gravelly sandy loam | Very friable | 2.5-5.0 | 5.1-5.5 | Gravelly sandy loam glacial basal till | Very hard, strongly cemented | Less than 0.05 | 5.1-5.5 | 30.0 | 4.5 |
| Hovde | Beach deposits | Silty clay loam, loam, loamy sand, gravelly sandy loam, sand | 0.25-1.0 | Sands | Loose | 0.2-0.8 | 7.0-7.5 | Beach sands | Loose | 5.0-10.0 | 7.0-7.5 | 12.0 | 4.0-5.5 |
| Hoypus | Upland terrace | Coarse sandy loam, gravelly loamy sand | 0.5-1.0 | Loamy sand | Loose | 5.0-10.0 | 5.6-6.0 | Very gravelly sands. Glacial ablation till | Loose | 5.0-10.0 | 5.6-6.0 | 20.0-24.0 | 4.0-5.0 |

Table 6. Properties of soils in Puget Sound Area. 1/ (con.)

| Soil Series or Land Types | Topographic Position | Surface Soils | | Subsoils | | | | Substrata | | | | Depth of Root Penetration | Water Holding Capacity |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Textures | Water Intake Rates | Textures | Consistence | Permeability | Reaction pH | Textures and/or Parent Material | Consistence | Permeability | Reaction pH | | |
| | | | (in/hr) | | | (in/hr) | | | | (in/hr) | | (inches) | (inches) |
| Indianola 2/ | Upland terrace | Fine sandy loam, loamy sand, sandy loam, loamy fine sand, silt loam and loam | 0.3-1.1 | Loamy fine sand, fine sand, loamy sand | Loose | 2.5-5.0 | 4.5-6.5 | Sands and loamy sands. Glacial ablation till | Loose | 5.0-10.0 | 6.1-6.8 | 40.0-60.0 | 4.0-5.8 |
| Issaquah | Alluvial flood plain | Silt loam | 0.2-0.5 | Silty clay loam | Hard, sticky and plastic | 0.05-0.2 | 6.1-6.5 | Micaceous sandy clay and sandy clay loam stratified alluvium | Hard, slightly sticky and plastic | Less than 0.05 | 6.5-7.0 | 12.0-20.0 | 6.0-8.0 |
| Juno | Alluvial flood plain | Sandy loam, gravelly sandy loam, loam, loamy sand | 0.9-1.0 | Sandy loam and loamy sands | Loose | 5.0-10.0 | 5.1-5.5 | Cobbly and stony sands. Alluvium | Loose | Over 10.0 | 5.1-5.5 | 12.0-20.0 | 4.0-5.5 |
| Jolley (Triton) | Upland | Very gravelly loam | 0.9-1.0 | Very gravelly loam | Friable | 0.8-2.5 | 6.1-6.5 | Very gravelly sandy loam. Strongly cemented Colluvial & alluvial basal till | Very hard, strongly cemented | Less than 0.05 | 6.1-6.5 | 12.0-20.0 | 2.0-3.0 |
| Kapowsin 2/ | Upland terrace | Gravelly loam, gravelly clay loam, gravelly sandy loam | 0.2-0.5 | Gravelly clay loam | Very firm, sticky and plastic | 0.2-0.8 | 5.6-6.0 | Gravelly sandy loam. Platy. Basal till. | Very hard, strongly cemented | 0.05-0.2 | 6.1-6.5 | 24.0-36.0 | 3.3-5.5 |

Table 6. Properties of soils in Puget Sound Area. 1/ (con.)

| Soil Series or Land Types | Topographic Position | Surface Soils | | Subsoils | | | | Substrata | | | | Depth of Root Penetration | Water Holding Capacity |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Textures | Water Intake Rates | Textures | Consistence | Permeability | Reaction pH | Textures and/or Parent Material | Consistence | Permeability | Reaction pH | | |
| | | | (in/hr) | | | (in/hr) | | | | (in/hr) | | (inches) | (inches) |
| Keystone | Upland terrace | Loamy sand, fine sandy loam | 0.5-1.1 | Loamy sand | Loose | 5.0-10.0 | 5.6-6.0 | Coarse and medium sands with gravel. Ablation till | Loose | 5.0-10.0 | 5.6-6.6 | 36.0-48.00 | 3.5-4.0 |
| Kickerville | Upland terrace | Silt loam | 0.2-0.5 | Gravelly loam | Compact | 2.5-5.0 | 6.1-6.5 | Gravelly sands over stony clay basal till at about 10 feet | Loose to 10 feet Very hard, plastic below 10 feet | 5.0-10.0 to less than 0.05 at 10 feet | 6.1-7.0 | 48.0-60.0 | 6.0-8.0 |
| Kitsap 2/ | Upland terrace | Silt loam silty clay loam, loam, gravelly loam | 0.2-0.5 | Silt loam and silty clay loam. Laminated | Firm, hard, slightly sticky, slightly plastic | 0.05-0.2 | 5.6-6.0 | Silt loam and fine sandy loam, laminated. Glacial lake or marine sediments | Very firm, hard, slightly sticky, slightly plastic | Less than 0.05 | 6.1-6.5 | 20.0-40.0 | 6.0-7.0 |
| Klaber | Upland | Silty clay loam | 0.15-3.0 | Silty clay loam | Very hard, very plastic | 0.05-0.2 | 5.1-5.5 | Silty clay. Pre-Pleistocene terrace | Very hard, very plastic | Less than 0.05 | 5.6-6.0 | 24.0-30.0 | 4.0-4.5 |
| Klaus | Upland terrace | Gravelly loam, gravelly sandy loam | 0.5-1.1 | Gravelly loam | Very friable | 2.5-5.0 | 5.1-5.5 | Very gravelly sands and loamy sands | Loose | 5.0-10.0 | 5.6-6.5 | 36.0-48.0 | 3.3-4.5 |
| Kline | Alluvial bottomlands | Silt loam, loam, gravelly loam, sandy loam | 0.2-1.0 | Loam, silt loam or sandy loam | Firm | 0.8-2.5 | 5.1-5.5 | Sandy loam, gravelly sandy loam, or loamy fine sand | Very friable | 2.5-5.0 | 5.6-6.0 | 36.0-60.0 | 3.6-5.4 |

Table 6. Properties of soils in Puget Sound Area. 1/ (con.)

| Soil Series or Land Types | Topographic Position | Surface Soils | | Subsoils | | | | Substrata | | | | Depth of Root Penetration | Water Holding Capacity |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Textures | Water Intake Rates | Textures | Consistence | Permeability | Reaction pH | Textures and/or Parent Material | Consistence | Permeability | Reaction pH | | |
| | | | (in/hr) | | | (in/hr) | | | | (in/hr) | | (inches) | (inches) |
| Koch | Bottomland. Flood plains | Gravelly loam, gravelly sandy loam, silt loam | 0.2-0.5 | Gravelly sandy loam | Hard to partially cemented with iron | 0.2-0.8 | 5.6-6.0 | Gravel and sand alluvium | Grading from cemented to loose | 0.05-0.2 | 5.6-6.0 | 24.0-28.0 | 3.3-6.0 |
| Kopiah | Upland | Silt loam, loam, silty clay loam | 0.15-0.3 | Clay | Extremely hard, very sticky, very plastic | 0.2-0.8 | 5.1-5.5 | Clay loam | Extremely hard, sticky, plastic | Less than 0.05 | 5.1-5.5 | 18.0-24.0 | 4.5 |
| Labounty | Upland terrace | Silt loam | 0.2-0.5 | Clay loam | Very hard, sticky, plastic | 0.05-0.2 | 5.6-6.0 | Gravelly and stony clay. Basal till | Extremely hard, sticky and plastic | Less than 0.05 | 6.1-6.5 | 18.0-30.0 | 5.0-6.0 |
| Lummi | Bottomland. Flood plains | Silty clay loam, silt loam, fine sandy loam | 0.15-0.5 | Silty clay loam | Hard, sticky and plastic | 0.05-0.2 | 6.1-6.5 | Silts and clay. Stratified. | Hard, sticky and plastic | 0.05-0.2 | 6.1-6.5 | 48.0-60.0 | 6.5-10.0 |
| Lynden 2/ | Upland terrace | Loamy sand, sandy loam, gravelly sandy loam, loam, gravelly loam | 0.2-1.0 | Loamy sand | Loose | 2.5-5.0 | 5.1-5.5 | Loamy sands, ablation till | Loose | 5.0-10.0 | 5.6-6.0 | 36.0-60.0 | 5.7-10.0 |

Table 6. Properties of soils in Puget Sound Area. 1/ (con.)

| Soil Series or Land Types | Topographic Position | Surface Soils | | Subsoils | | | | Substrata | | | | Depth of Root Penetration | Water Holding Capacity |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Textures | Water Intake Rates | Textures | Consistence | Permeability | Reaction pH | Textures and/or Parent Material | Consistence | Permeability | Reaction pH | | |
| | | | (in/hr) | | | (in/hr) | | | | (in/hr) | | (inches) | (inches) |
| Lystair | Upland terrace | Loamy sand, sandy loam fine sandy loam | 0.5-1.0 | Loamy sand | Loose | 5.0-10.0 | 5.6-6.0 | Sand Ablation till | Loose | 5.0-10.0 | 5.6-6.0 | 24.0-36.0 | 5.0-6.0 |
| Marblemount | Upland | Stony loam | 0.2-0.5 | Stony loam | Friable | 0.8-2.5 | 5.6-6.0 | Granite or granodiorite | Indurated | Less than 0.05 | --- | 20.0-30.0 | 4.8 |
| Maytown 2/ | Flood plains | Silt loam, fine sandy loam | 0.2-0.5 | Silty clay loam, clay | Hard, sticky and plastic | 0.8-2.5 | 6.1-7.0 | Silty clay loam or silt loam | Hard, sticky and plastic | 0.05-0.2 | 6.1-7.0 | 20.0-36.0 | 10.0 |
| McKenna 2/ | Upland terrace | Gravelly clay loam, silty clay loam, loam gravelly loam | 0.15-0.5 | Loam or clay loam | Hard, sticky and plastic | 0.2-0.8 | 5.1-5.5 | Sandy clay loam, basal till, sandy clay laminated | Very hard, sticky and plastic | Less than 0.05 | 5.1-6.1 | 20.0-30.0 | 4.0-5.0 |
| McMurray and Semiahmoo | Upland terrace and bottom-land basins | Muck | 0.3-0.5 | Peat, woody peat, sedge | Fibrous | Variable 0.2-5.0 | 5.6-6.0 | Peat, woody, sedge or sedimentary | Fibrous or very soft and liquid | 0.05-0.2 | 5.6-6.0 | 20.0-24.0 | 10.0 + |
| Melbourne 2/ | Upland | Loam, stony loam | 0.2-0.5 | Silty clay loam to silty clay | Hard, sticky and very plastic | 0.2-0.8 | 5.2-6.0 | Silty clay grading to shale bedrock | Very hard, sticky and very plastic | 0.05-0.2 | 4.8-6.1 | 36.0-48.0 | 4.8-6.4 |

Table 6. Properties of soils in Puget Sound Area. 1/ (con.)

| Soil Series or Land Types | Topographic Position | Surface Soils: Textures | Surface Soils: Water Intake Rates (in/hr) | Subsoils: Textures | Subsoils: Consistence | Subsoils: Permeability (in/hr) | Subsoils: Reaction pH | Substrata: Textures and/or Parent Material | Substrata: Consistence | Substrata: Permeability (in/hr) | Substrata: Reaction pH | Depth of Root Penetration (inches) | Water Holding Capacity (inches) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| McMurray (Rifle) Mukilteo 2/ | Upland and terrace basins | Peat, woody peat, sedge | 0.3-0.5 | Peat, woody peat, sedge | Fibrous | 0.8-2.5 | 5.1-7.0 | Peat, woody, sedge or sedimentary, basal till, sand, gravel or clay | -- | 0.05-0.2 | 5.1-7.0 | 12.0-60.0 | 5.0-12.0 |
| National | Upland terrace | Pumicy sandy loam, pumicy loam, gravelly sandy loam | 0.5-1.0 | Pumicy sandy loam | Loose | 5.0-10.0 | 5.1-5.5 | Clay loam | Compact | 0.2-0.8 | 5.6-6.0 | 36.0-48.0 | 5.0-6.0 |
| Neptune | Bottomland | Sandy loam, gravelly sandy loam (shells) | 0.5-1.0 | Loamy sand | Loose | 2.5-5.0 | 7.3-7.6 | Coarse sand | Loose | 5.0-10.0 | 7.3-7.6 | 20.0-30.0 | 5.0-6.0 |
| Nesika | Terrace | Loam | 0.2-0.5 | Loam | Firm | 0.8-2.5 | 6.1-6.5 | Gravelly sandy loam. Low terrace | Loose | 2.5-5.0 | 4.5-5.0 | 20.0-30.0 | 6.0-8.0 |
| Newberg 2/ | Bottomland. Flood plains | Sandy loam, fine sandy loam, loamy fine sand, loamy sand, silt loam, loam | 0.5-1.1 | Sand, fine sand, fine sandy loam | Loose | 2.5-5.0 | 5.6-6.0 | Sands and fine sands | Loose | 5.0-10.0 | 5.6-6.0 | 30.0-48.0 | 5.0-7.0 |
| Nisqually 2/ | Upland terrace | Loamy sand, sand | 0.5-1.1 | Sands, fine sands | Loose | 2.5-5.0 | 5.6-6.0 | Sands | Loose | 5.0-10.0 | 5.6-6.0 | 40.0-60.0 | 3.5-5.0 |

Table 6. Properties of soils in Puget Sound Area. 1/ (con.)

| Soil Series or Land Types | Topo-graphic Position | Surface Soils | | Subsoils | | | | Substrata | | | | Depth of Root Penetration | Water Holding Capacity |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Textures | Water Intake Rates | Textures | Consistence | Permeability | Reaction pH | Textures and/or Parent Material | Consistence | Permeability | Reaction pH | | |
| | | | (in/hr) | | | (in/hr) | | | | (in/hr) | | (inches) | (inches) |
| Olympic 2/ | Upland | Silty clay loam, stony clay loam | 0.1-0.3 | Silty clay loam or stony silty clay loam | Firm, hard, very sticky, very plastic | 0.2-0.8 | 4.5-5.0 | Gravelly or stony clay loam, grading to basalt bedrock | Hard to sticky and plastic | 0.2-0.8 | 4.5-5.0 | 12.0-48.0 | 4.0-10.0 |
| Orcas | Basins | Sphagnum peat | 0.35-0.5 | Sphagnum peat | Fibrous soft | 0.8-2.5 | 4.5-5.0 | Sphagnum and/or sedimentary peat | Fibrous to very soft | 0.8-2.5 | 4.5-5.0 | 12.0-20.0 | 5.0-10.0 |
| Orcas, shallow | Basins | Sphagnum peat | 0.35- | Very grav. sands | Firm | 0.05-0.2 | 4.5-5.0 | Very grav. sands | Firm, hard | Less than 0.05 | 4.5-5.0 | 12.0-20.0 | 5.0-6.0 |
| Orting | Upland terrace | Gravelly sandy loam, loam, sandy loam, stony sandy loam | 0.2-0.75 | Very gravelly or cobbly loam | Hard, compact | 0.05-0.2 | 5.6-6.0 | Gravelly, cobbly or stony loam | Very hard and compact | 0.05-0.2 | 5.6-6.0 | 24.0-36.0 | 3.0-4.0 |
| Oso | Upland | Silt loam | 0.2-0.5 | Loam or silty clay loam | Compact | 0.2-0.8 | 5.1-5.5 | Silty clay loam over argillite bedrock | Very hard | 0.05-0.2 | 5.1-5.5 | 20.0 40.0 | 5.0-7.0 |
| Pickett - Rock complex | Upland | Rocky loam | 0.3- | Rocky loam or sandstone bedrock | Compact | 0.8-2.5 | 6.1-6.5 | Sandstone bedrock | Very hard | Less than 0.05 | --- | 12.0-20.0 | 3.0-6.0 |
| Pilchuck 2/ | Alluvial flood plains | Fine sand, sand, grav. sand, loamy sand, fine sandy loam, grav. loamy sand, loamy fine sand | 0.4-1.1 | Loamy sands or gravelly loamy sands | Loose | 5.0-10.0 | 6.6-7.3 | Sands, gravelly sands or very gravelly sands | Loose | Over 10.0 | 6.6-7.3 | 12.0-40.0 | 2.4-5.7 |

Table 6. Properties of soils in Puget Sound Area. 1/ (con.)

| Soil Series or Land Types | Topographic Position | Surface Soils | | Subsoils | | | | Substrata | | | | Depth of Root Penetration | Water Holding Capacity |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Textures | Water Intake Rates | Textures | Consistence | Permeability | Reaction pH | Textures and/or Parent Material | Consistence | Permeability | Reaction pH | | |
| | | | (in/hr) | | | (in/hr) | | | | (in/hr) | | (inches) | (inches) |
| Nookachamps | Alluvial flood plain | Silt loam silty clay loam | 0.10-0.5 | Silty clay loam, silt loam and sandy loam, stratified | Plastic | 0.2-0.8 | 6.1-6.5 | Silty clay or clay alluvium | Very sticky, very plastic | Less than 0.05 | 6.6-7.3 | 24.0 | 6.5-10.0 |
| Nooksack | Alluvial flood plain | Silt loam, fine sandy loam | 0.2-0.5 | Silt loam | Compact | 0.2-0.8 | 6.1-6.5 | Silty clay loam, silt loam and fine sandy loam, stratified | Compact slightly plastic | 0.05-0.2 | 6.1-6.5 | 40.0-60.0 | 8.0-11.0 |
| Nordby | Upland terrace | Loam | 0.2-0.5 | Loam | Friable | 0.8-2.5 | 5.1-5.5 | Gravelly sandy loam | Very friable | 5.0-10.0 | 5.1-5.5 | 30.0-36.0 | 5.8-7.0 |
| Norma 2/ | Terrace basin | Loam, clay loam, sandy loam, fine sandy loam, silt loam, silty clay loam | 0.2-0.5 | Silty clay, sandy clay loam, loamy sand or sandy loam | Firm to weakly iron cemented | 0.05-0.2 | 5.6-6.0 | Stratified fine sandy loam, sandy loam, loam, or gravelly sandy loam | Firm to weakly cemented | Variable 0.05-2.5 | 6.1-6.5 | 20.0-48.0 | 4.3-6.5 |
| Nuby | Alluvial flood plain | Silt loam | 0.2-0.5 | Silt Loam | Firm | 0.2-0.8 | 5.1-5.5 | Sands and silt stratified alluvium | Loose to firm | 2.5-5.0 | 5.1-5.5 | 30.0-40.0 | 6.4-8.4 |
| Olete | Upland | Very gravelly silt loam | 0.2-0.5 | Very gravelly silt loam or loam | Sticky | 0.8-2.5 | 6.6-7.3 | Basalt bedrock | Very hard | Less than 0.05 | -- | 12.0- | 2.5-3.7 |

Table 6. Properties of soils in Puget Sound Area. 1/ (con.)

| Soil Series or Land Types | Topographic Position | Surface Soils | | Subsoils | | | | Substrata | | | | Depth of Root Penetration | Water Holding Capacity |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Textures | Water Intake Rates | Textures | Consistence | Permeability | Reaction pH | Textures and/or Parent Material | Consistence | Permeability | Reaction pH | | |
| | | | (in/hr) | | | (in/hr) | | | | (in/hr) | | (inches) | (inches) |
| Pondilla | Upland terrace | Fine sand | 0.3-0.75 | Fine sand | Loose | 5.0-10.0 | 6.1-6.5 | Medium and fine sands. Ablation till | Loose | 5.0-10.0 | 6.1-6.5 | 20.0-40.0 | 4.5-7.5 |
| Prather 2/ | Upland terrace | Silty clay loam | 0.1-0.75 | Silty Clay | Firm hard, sticky plastic | 0.05-0.2 | 6.1-6.5 | Clay or silty clay | Firm v.hard v.sticky very plastic | Less than 0.05 | 6.1-6.5 | 20.0-30.0 | 4.5-5.0 |
| Puget 2/ | Alluvial flood plains | Silty clay loam, clay loam, loam, silt loam clay, silty clay, fine sandy loam, very fine sandy loam | 0.1-0.75 | Silt loam, silty clay loam or clay | Firm, hard, sticky plastic to very plastic | 0.2-0.8 | 5.1-5.5 | Silty clay loam or clay | Firm, hard, very sticky very plastic | 0.05-0.2 | 5.1-5.5 | 40.0-60.0 | 8.5- |
| Puyallup 2/ | Alluvial flood plains | Sandy loam, fine sandy loam, silt loam, loam, very fine sandy loam, loamy fine sand, silty clay loam | 0.2-0.75 | Fine sandy loam, very fine sandy loam | Loose | 0.8-2.5 | 6.1-6.5 | Fine sandy loam to fine sand | Loose | 5.0-10.0 | 6.1-6.5 | 40.0-60.0 | 5.0-8.0 |
| Quilcene | Upland | Silty clay loam | 0.1-0.4 | Silty clay loam | Hard, sticky and plastic | 0.2-0.8 | 5.6-6.0 | Silty clay loam over shale | Hard, sticky and plastic | 0.05-0.2 | 5.6-6.0 | 30.0-40.0 | 6.4-10.0 |
| Rifle - see 2/ McMurray | | | | | | | | | | | | | |

Table 6. Properties of soils in Puget Sound Area, 1/ (con.)

| Soil Series or Land Types | Topographic Position | Surface Soils | | Subsoils | | | | Substrata | | | | Depth of Root Penetration | Water Holding Capacity |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Textures | Water Intake Rates | Textures | Consistence | Permeability | Reaction pH | Textures and/or Parent Material | Consistence | Permeability | Reaction pH | | |
| | | | (in/hr) | | | (in/hr) | | | | (in/hr) | | (inches) | (inches) |
| Ragnar | Upland terrace | Fine sandy loam | 0.3-0.5 | Fine sandy loam | Loose | 5.0-10.0 | 5.6-6.0 | Stratified sands and gravels | Loose | 5.0-10.0 | 6.1-6.5 | 36.0-60.0 | 3.5-5.0 |
| Reed 2/ | Flood plain | Clay | Less than 0.05 | Clay | Hard sticky plastic | Less than 0.05 | 5.8 | Clay or silty clay | Hard sticky plastic | Less than 0.05 | 5.8 | 10.0-18.0 | 2.0-3.0 |
| Riverwash 2/ | Flood plains | Sand, gravel and cobbles | 5.0-10.0 | Sand, gravel and cobbles | Loose | 5.0-10.0 | 6.1-6.5 | Gravelly and cobbly sands | Loose | 5.0-10.0 | 6.1-6.5 | --- | 2.5 |
| Roche | Upland terrace | Grav. loam, loam, stony loam, grav. sandy loam, stony sandy loam | 0.2-0.75 | Fine sandy loam, platy | Hard, plastic and sticky | 0.05-0.2 | 5.6-6.0 | Fine sandy loam, sandy clay loam, thin, platy. Glacial basal till | Very hard, sticky and plastic | Less than 0.05 | 5.6-6.0 | 24.0-48.0 | 4.8-6.4 |
| Rock Land | Upland | Variable, stony and rocky loams | 0.2-0.4 | Stony and rocky loams | Hard | 0.2-0.8 | 5.6-6.0 | Bedrock of basalt, argillite or sandstone | Very hard | Less than 0.05 | --- | Variable 0.0-36.0 | 0.0-3.6 |
| Rough broken land | Upland | Sandy loams; gravelly sandy loams, loams and gravelly loams | 0.2-0.75 | Gravelly loams, loams, sandy loams, gravelly sandy loams, stony loams and stony sandy loams | Friable hard to loose | 0.2-0.8 | 5.6-6.0 | Variable gravelly or stony loams or sandy loams or sands. On bedrock or glacial ablation or basal till. | Variable very hard to loose | 0.2-0.8 | 5.6-6.5 | Variable 10.0-48.0 | 2.5-8.0 |

Table 6. Properties of soils in Puget Sound Area. 1/ (con.)

| Soil Series or Land Types | Topographic Position | Surface Soils | | Subsoils | | | | Substrata | | | | Depth of Root Penetration | Water Holding Capacity |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Textures | Water Intake Rates | Textures | Consistence | Permeability | Reaction pH | Textures and/or Parent Material | Consistence | Permeability | Reaction pH | | |
| | | | (in/hr) | | | (in/hr) | | | | (in/hr) | | (inches) | (inches) |
| Rough mountainous | Upland | Loams, stony rocky and cobbly loams and rock outcrop | 0.2-0.5 or 0.0 | Variable rocky, stony and cobbly | Firm to very hard | Variable 0.05-2.5 | 5.1-5.5 | Loams or bedrock of basalt, argillite, sandstone, granite | Very hard | Variable 0.0-2.5 | --- | Variable 0.0-48.0 + | 0.0-6.0 |
| Rough stony land | Upland | Stony and rocky loams or sandy loams | 0.2-0.75 | Variable stony and rocky loams or sandy loams | Variable | Variable 0.05-2.5 | 5.1-5.5 | Variable stony or rocky loams over glacial ablation or basal till, or bedrock | Loose to very hard | Variable | 5.1-5.5 | Variable | 2.5-5.0 |
| Salal | Alluvial low terrace | Silt loam, fine sandy loam | 0.2-0.5 | Silt loam or fine sandy loam | Friable | 0.2-0.8 | 5.6-6.0 | Silt loam | Friable | 0.8-2.5 | 6.1-6.5 | 40.0-60.0 | 5.0-7.0 |
| Samish | Alluvial flood plain | Micaceous silty clay loam, silt loam | 0.1-0.5 | Silt loam or silty clay loam | Firm | 0.2-0.8 | 5.6-6.0 | Micaceous silty clay or clay | Firm plastic | 0.05-0.2 | 5.6-6.0 | 40.0-60.0 | 7.0-10.0 |
| Sammamish | Alluvial flood plain | Silt loam | 0.2-0.5 | Silty clay loam | Hard, sticky and plastic | 0.05-0.2 | 6.6-7.3 | Sandy clay and sand, stratified | Hard, sticky and plastic | 0.05-0.2 | 7.3-7.7 | 30.0-40.0 | 6.0-7.0 |
| San Juan | Upland terrace | Grav. sandy loam, loam, stony loam, stony sandy loam, coarse sandy loam | 0.3-1.1 | Gravelly loamy sand | Loose | 5.0-10.0 | 6.1-6.5 | Gravel and sand ablation till | Loose | 5.0-10.0 | 6.1-6.5 | 20.0-40.0 | 4.8-5.8 |

Table 6. Properties of soils in Puget Sound Area. 1/ (con.)

| Soil Series or Land Types | Topo-graphic Position | Surface Soils | | Subsoils | | | | Substrata | | | | Depth of Root Penetra-tion | Water Holding Capa-city |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Textures | Water Intake Rates | Textures | Consis-tence | Permea-bility | Reaction pH | Textures and/or Parent Material | Consis-tence | Permea-bility | Reaction pH | | |
| | | | (in/hr) | | | (in/hr) | | | | (in/hr) | | (inches) | (inches) |
| San Juan, moderately deep | Upland terrace | Gravelly sandy loam | 0.3-0.75 | Gravelly loam | Hard, sticky, slightly plastic | 0.8-2.5 | 6.1-6.5 | Gravelly sandy clay loam, glacial basal till | Extremely hard, sticky plastic | 0.05-0.2 | 6.1-6.5 | 18.0-24.0 | 4.0-5.0 |
| Sauk | Upland terrace | Loam | 0.2-0.5 | Fine sandy loam, loam | Firm | 0.8-2.5 | 4.5-5.0 | Sand or loamy sand. Low terrace | Loose | 2.5-5.0 | 5.6-6.0 | 40.0-60.0 | 8.0-10.0 |
| Saxon | Upland terrace | Silt loam | 0.2-0.5 | Silty clay loam, laminated | Firm | 0.2-0.8 | 5.1-6.5 | Silty clay loam and silt loam | Compact hard | 0.05-0.2 | 5.6-6.5 | 20.0-40.0 | 4.8-6.4 |
| Schnorbush | Upland terrace | Loam | 0.2-0.5 | Gritty loam or clay loam with sandstone fragments | Firm | 0.2-0.8 | 5.6-6.0 | Gravelly, bouldery or stony clay or clay loam over sand-stone rubble | Firm, sticky plastic | 0.2-0.8 | 5.6-6.0 | 20.0-30.0 | 5.6-6.0 |
| Schooley | Low terrace basin | Loam | 0.2-0.5 | Pumicy sands | Firm weakly cemented | 2.5-5.0 | 5.6-6.0 | Clay | Very hard sticky and plastic | Less than 0.05 | 6.1-6.5 | 30.0-40.0 | 2.4 |
| Semiahmoo 2/ | Upland terrace and bottom-land basins | Muck | 0.3-0.5 | Peat, sedge | Fibrous soft | 0.8-2.5 | 5.6-6.0 | Peat, sedge or sedimentary | Sedge fibrous soft sedi-mentary very soft to liquid | Variable 0.2-2.5 | 6.1-6.5 | 36.0-60.0 | 10.0-12.0 |

Table 6. Properties of soils in Puget Sound Area. 1/ (con.)

| Soil Series or Land Types | Topographic Position | Surface Soils | | Subsoils | | | | Substrata | | | | Depth of Root Penetration | Water Holding Capacity |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Textures | Water Intake Rates | Textures | Consistence | Permeability | Reaction pH | Textures and/or Parent Material | Consistence | Permeability | Reaction pH | | |
| | | | (in/hr) | | | (in/hr) | | | | (in/hr) | | (inches) | (inches) |
| Semiahmoo, 2/ shallow | Upland terrace and bottom-land basins | Muck | 0.3-0.5 | Muck or sedge peat | Fibrous soft | 0.8-2.5 | 5.6-6.0 | Compact sands gravelly sands, or silt or clays | Hard | 0.05-0.2 | 5.1-7.3 | 10.0-20.0 | 3.5-5.0 |
| Sequim | Upland terrace | Clay loam, gravelly loam | 0.1-0.5 | Gravelly sandy loam, cobbly sandy loam, gravelly loam | Firm | 0.8-2.5 | 6.6-7.3 | Very gravelly or cobbly sands | Firm | 0.2-0.8 | 6.6-7.3 | 20.0-36.0 | 5.0-6.5 |
| Shelton | Upland terrace | Gravelly loam, gravelly sandy loam | 0.2-0.75 | Gravelly sandy loam | Very friable | 0.8-2.5 | 5.6-6.0 | Gravelly sandy loam | Very hard, strongly cemented | 0.05-0.2 | 5.6-6.0 | 20.0-30.0 | 4.0-5.0 |
| Shuwah 2/ | Alluvial flood plains | Silty clay loam | 0.1-0.3 | Silty clay loam | Firm, sticky and plastic | 0.2-0.8 | 5.6-6.0 | Silty clay loam. Alluvium | Firm, slightly sticky, slightly plastic | 0.2-0.8 | 5.6-6.0 | 36.0-60.0 | 10.0-11.0 |
| Sinclair | Upland terrace | Shotty loam, gravelly fine sandy loam, grav. sandy loam, grav. loam clay loam | 0.1-0.75 | Silt loam, gravelly sandy loam | Friable | 0.2-0.8 | 5.1-6.0 | Gravelly sandy loam, gravelly sands | Very compact Moderately cemented | 0.05-0.2 | 5.6-6.0 | 24.0-36.0 | 3.5-6.0 |

Table 6. Properties of soils in Puget Sound Area. 1/ (con.)

| Soil Series or Land Types | Topographic Position | Surface Soils: Textures | Surface Soils: Water Intake Rates (in/hr) | Subsoils: Textures | Subsoils: Consistence | Subsoils: Permeability (in/hr) | Subsoils: Reaction pH | Substrata: Textures and/or Parent Material | Substrata: Consistence | Substrata: Permeability (in/hr) | Substrata: Reaction pH | Depth of Root Penetration (inches) | Water Holding Capacity (inches) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Skagit | Low terraces and flood plains | Silty clay loam | 0.1-0.3 | Silty clay loam with shale and schist fragments | Firm | Less than 0.05 | 5.6-6.0 | Shale, schist and argillite, stratified | Very firm, non-sticky and non-plastic | Less than 0.05 | 5.6-6.0 | 10.0-24.0 | 4.4-6.0 |
| Skiyou | Upland terraces | Gravelly loam | 0.2-0.5 | Gravelly loam | Friable | 0.2-0.8 | 5.1-5.5 | Gravelly sandy loam glacial basal till | Very compact, strongly cemented | 0.05-0.2 | 6.1-6.5 | 24.0-36.0 | 3.5-5.0 |
| Skokomish | Alluvial flood plain | Silt loam | 0.2-0.5 | Silt loam | Friable | 0.2-0.8 | 5.6-6.0 | silt | Compact firm | 0.05-0.2 | 5.6-6.0 | 30.0-48.0 | 8.0-11.0 |
| Skykomish | Upland terrace | Cobbly sandy loam, stony loam, gravelly loam, gravelly sandy loam, stony sand, gravelly sand | 0.4-1.1 | Gravelly or stony sandy loam or sands | Loose | 5.0-10.0 | 5.6-6.0 | Sands, gravels and cobbles. Glacial ablation till | Loose | Over 10.0 | 5.6-6.0 | 36.0-60.0 | 2.8-3.5 |
| Smith Creek | Upland terrace | Gravelly loam | 0.4-0.75 | Very gravelly sands | Loose | 0.8-2.5 | 5.6-6.0 | Very gravelly coarse sand | Loose | Variable 2.5-10.0 | 6.1-6.5 | 20.0-30.0 | 4.5-6.0 |
| Snakelum | Upland terrace | Coarse sandy loam | 0.55-1.1 | Sandy loam and coarse loamy sand | Firm to loose | 5.0-10.0 | 5.6-6.0 | Coarse sands, glacial ablation till | Loose | 5.0-10.0 | 6.1-6.5 | 36.0-60.0 | 5.0-6.0 |

Table 6. Properties of soils in Puget Sound Area. 1/ (con.)

| Soil Series or Land Types | Topo-graphic Position | Surface Soils | | Subsoils | | | | Substrata | | | | Depth of Root Penetration | Water Holding Capacity |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Textures | Water Intake Rates | Textures | Consistence | Permeability | Reaction pH | Textures and/or Parent Material | Consistence | Permeability | Reaction pH | | |
| | | | (in/hr) | | | (in/hr) | | | | (in/hr) | | (inches) | (inches) |
| Snohomish 2/ | Alluvial basin | Silt loam, loam, fine sandy loam, silty clay loam, silty clay, loamy fine sand | 0.1-0.5 | Silty clay | Firm, sticky and plastic | 0.05-0.8 | 5.6-6.5 | Woody, sedge, moss and sedimentary peats | Soft | 0.2-0.8 | 5.6-6.5 | 20.0-30.0 | 5.5-10.0 |
| Snoqualmie | Upland terrace | Gravelly loam, gravelly sandy loam, gravelly loamy sand | 0.4-0.75 | Very gravelly sands | Loose | 2.5-5.0 | 5.6-6.0 | Gravels, sands and cobbles | Loose | 5.0-10.0 | 5.6-6.0 | 20.0-30.0 | 4.0-5.0 |
| Sol Duc | Upland terraces | Gravelly loam, gravelly sandy loam | 0.3-0.75 | Very gravelly sandy loams and loamy sands | Firm | 2.5-5.0 | 4.5-5.0 | Gravel, cobbles, boulders and sands. Stratified glacial ablation till | Loose | 5.0-10.0 | 5.1-5.5 | 20.0-30.0 | 4.0 |
| Spalding | Bottom-land basins | Peat | 0.35-0.5 | Peat | Felty, soft | 0.2-0.8 | 4.5-5.0 | Peat | Felty, soft | 0.2-0.8 | 4.5-5.0 | 12.0-30.0 | 7.5 |
| Spanaway 2/ | Upland terrace | Gravelly sandy loam, gravelly silt loam, stony loam | 0.2-0.75 | Very gravelly and cobbly sandy loam | Loose | 5.0-10.0 | 5.1-5.5 | Gravelly, cobbles and sands. Glacial ablation till | Loose | More than 10.0 | 6.1-6.5 | 12.0-30.0 | 5.0-6.0 |

Table 6. Properties of soils in Puget Sound Area. 1/ (con.)

| Soil Series or Land Types | Topographic Position | Surface Soils | | Subsoils | | | | Substrata | | | | Depth of Root Penetration | Water Holding Capacity |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Textures | Water Intake Rates | Textures | Consistence | Permeability | Reaction pH | Textures and/or Parent Material | Consistence | Permeability | Reaction pH | | |
| | | | (in/hr) | | | (in/hr) | | | | (in/hr) | | (inches) | (inches) |
| Squalicum | Upland terrace | Gravelly silt loam, silt loam, stony silt loam | 0.2-0.5 | Silty clay loam containing gravel and a few cobbles | Firm | 0.2-0.8 | 5.1-5.5 | Gravelly sandy clay with gravel stone and boulders. Glacial basal till | Hard, weakly cemented | Less than 0.05 | 5.1-5.5 | 20.0-30.0 | 4.8-6.0 |
| Steep broken land | Upland and upland terrace | Extremely variable gravelly or cobbly loams, sandy loams or loamy sands | 0.3-0.5 | Extremely variable gravelly or cobbly loams, sandy loams or sands | Firm to loose | 0.2-0.8 | 5.6-6.0 | Gravels, sands, cobbles or stone. Glacial basal or glacial ablation till | Variable loose strongly cemented | Variable 0.05-5.0 | 5.6-6.0 | 12.0-36.0 | 2.5-5.0 |
| Stossel | Upland | Stony loam, clay loam | 0.1-0.4 | Clay loam with shale, gravels and stones | Hard, sticky and plastic | 0.05-0.2 | 6.1-6.5 | Clay with stone and boulders. Argillaceous shale at about 50 inches | Very hard sticky and very plastic | Less than 0.05 | 6.1-6.5 | 12.0-24.0 | 4.0-5.0 |
| Sultan 2/ | Bottomland flood plains | Silt loam, clay loam, fine sandy loam, loamy sand | 0.1-0.5 | Silt loam | Slightly hard, friable, slightly sticky and plastic | 0.2-0.8 | 5.6-6.0 | Very fine sandy loam grading to loamy fine sand. Stream alluvium. | Soft, very friable non-sticky and non-plastic | 0.8-2.5 | 6.1-6.5 | 36.0-60.0 | 8.0-10.0 |
| Sumas | Bottomland basin | Silty clay loam, silt loam, fine sandy loam and loamy sand | 0.1-0.5 | Clay | Plastic | 0.2-0.8 | 6.1-6.5 | Fine and medium sands. Alluvium. | Loose | 0.2-0.8 | 6.1-6.5 | 20.0-48.0 | 10.0-11.0 |

Table 6. Properties of soils in Puget Sound Area. 1/ (con.)

| Soil Series or Land Types | Topographic Position | Surface Soils | | Subsoils | | | | Substrata | | | | Depth of Root Penetration | Water Holding Capacity |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Textures | Water Intake Rates | Textures | Consistence | Permeability | Reaction pH | Textures and/or Parent Material | Consistence | Permeability | Reaction pH | | |
| | | | (in/hr) | | | (in/hr) | | | | (in/hr) | | (inches) | (inches) |
| Swantown | Upland terrace | Gravelly sandy loam, loam, gravelly loam | 0.2-0.5 | Gravelly sandy loam | Firm | 0.2-0.8 | 5.6-6.0 | Sands and gravelly sands. Glacial basal till | Very hard. Very strongly cemented | Less than 0.05 | 6.1-6.5 | 14.0-20.0 | 5.0-6.0 |
| Tacoma 2/ | Tidal flats | Peat or muck | 0.3-0.5 | Peat or muck | Soft to very soft | 0.2-0.8 | 5.1-6.5 | Mixed sedimentary and fibrous peat and silts and clays. Tidal flat alluvium | Very soft | 0.2-0.8 | 5.1-6.5 | 12.0-36.0 | 5.0-7.5 |
| Tanwax | Upland basins | Colloidal peat | 0.1-0.4 | Colloidal or sedimentary peat | Very soft, spongy | 0.05-0.2 | 5.1-5.5 | Colloidal peat | Soft and spongy | Less than 0.05 | 4.5-5.5 | 24.0-30.0 | 5.0-7.0 |
| Tebo | Upland | Loam, gravelly loam | 0.2-0.5 | Clay loam | Hard, sticky and plastic | 0.2-0.8 | 5.1-5.5 | Clay loam or silty clay loam with basaltic gravel and cobbles grading into basalt bedrock | Very hard, sticky and plastic | 0.05-0.2 | 5.1-5.5 | 36.0-60.0 | 8.0-11.0 |
| Tenino 2/ | Upland terrace | Gravelly loam | 0.2-0.4 | Gravelly sandy loam or gravelly loamy sand | Loose, friable | 0.8-2.5 | 6.1-6.5 | Gravelly and cobbly sandy loam. Glacial basal till. | Hard, weakly cemented Grades into loose and friable | 0.2-0.8 | 6.1-6.5 | 20.0-36.0 | 6.0-8.0 |

Table 6. Properties of soils in Puget Sound Area. 1/ (con.)

| Soil Series or Land Types | Topo-graphic Position | Surface Soils | | Subsoils | | | | Substrata | | | | Depth of Root Penetra-tion | Water Holding Capa-city |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Textures | Water Intake Rates | Textures | Consis-tence | Permea-bility | Reaction pH | Textures and/or Parent Material | Consis-tence | Permea-bility | Reaction pH | | |
| | | | (in/hr) | | | (in/hr) | | | | (in/hr) | | (inches) | (inches) |
| Thornton | Upland basins | Clay, silty clay loam | 0.1-0.25 | Clay | Very hard, exceed-ingly greasy, modera-tely plastic | Less than 0.05 | 6.1-6.5 | Silty clay loam, alluvial materials from talc and micaceous rocks | Hard, slightly sticky and slightly plastic | Less than 0.05 | 6.1-6.5 | 8.0-20.0 | 3.5-4.5 |
| Thornwood | Upland terrace | Gravelly loam, gravelly sandy loam | 0.3-0.75 | Gravelly loam to gravelly sandy loam | Firm, friable | 2.5-5.0 | 5.6-6.0 | Gravelly sandy loam grading to sandy gravel with schist, shaly and flaggy grag-ments. Glacial ablation till from micaceous schist rocks. | Loose | 5.0-10.0 | 5.6-6.0 | 20.0-48.0 | 5.0-6.0 |
| Tidal Marsh 2/ | Tidal basins | Variable sands, silts, clays and organic materials | 0.2-0.5 | Sands, silts and clays | Very soft and spongy | 0.05-0.2 | 7.3-7.6 | Sands, silts, clay and organic materials | Very soft and spongy | 0.05-0.2 | 7.3-7.6 | Less than 12 inches | 4.2-6.6 |
| Tisch 2/ | Upland basins | Silt loam or silty clay loam | 0.1-0.4 | Silty diato-maceous earth | Firm and hard, sticky and slightly plastic | 0.05-0.2 | 5.6-6.5 | Fine sand. Alluvial material | Firm | 0.05-0.2 | 5.6-6.5 | 12.0-20.0 | 5.0-6.0 |

Table 6. Properties of soils in Puget Sound Area. 1/ (con.)

| Soil Series or Land Types | Topographic Position | Surface Soils: Textures | Surface Soils: Water Intake Rates (in/hr) | Subsoils: Textures | Subsoils: Consistence | Subsoils: Permeability (in/hr) | Subsoils: Reaction pH | Substrata: Textures and/or Parent Material | Substrata: Consistence | Substrata: Permeability (in/hr) | Substrata: Reaction pH | Depth of Root Penetration (inches) | Water Holding Capacity (inches) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Tokul | Upland terrace | Gravelly sandy loam | 0.4-0.75 | Gravelly sandy loam | Firm | 0.8-2.5 | 5.6-6.0 | Gravelly sandy loam with many stones and cobbles. Glacial basal till | Weakly to moderately cemented | 0.05-0.2 | 5.6-6.0 | 20.0-30.0 | 4.0-5.0 |
| Townsend | Upland terrace | Sandy loam, fine sandy loam, loam or gravelly loam | 0.3-0.75 | Sandy loam or gravelly sandy loam | Firm | 0.2-0.8 | 5.6-6.5 | Gravelly sandy loam. Glacial basal till. | Very hard, strongly cemented | 0.05-0.2 | 6.1-7.3 | 20.0-30.0 | 5.1-7.5 |
| Tromp | Upland terrace basin | Fine sandy loam, silt loam, silty clay loam | 0.2-0.5 | Fine sand or sandy loam | Very firm to moderately iron cemented. | 0.05-0.2 | 5.6-6.0 | Sands and fine sands | Compact to moderately iron cemented | 0.8-2.5 | 5.6-6.0 | 12.0-30.0 | 6.0-7.0 |
| Tumwater 2/ | Upland terrace | Fine sandy loam, loamy fine sand | 0.3-0.75 | Loamy fine sand | Loose | 5.0-10.0 | 6.6-7.3 | Fine sands and sands. Glacial ablation till. | Loose | 5.0-10.0 | 5.6-6.0 | 20.0-60.0 | 4.0-5.7 |
| Waddell 2/ | Upland terrace | Loam, gravelly loam, silty clay loam | 0.1-0.5 | Silty clay | Hard, sticky and plastic | 0.8-2.5 | 5.1-5.5 | Stratified gravelly sandy clay, loam, and sandy clay | Hard, sticky and plastic | 0.2-0.8 | 5.1-5.5 | 20.0-36.0 | 5.5-6.5 |

Table 6. Properties of soils in Puget Sound Area. 1/ (con.)

| Soil Series or Land Types | Topographic Position | Surface Soils | | Subsoils | | | | Substrata | | | | Depth of Root Penetration | Water Holding Capacity |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Textures | Water Intake Rates | Textures | Consistence | Permeability | Reaction pH | Textures and/or Parent Material | Consistence | Permeability | Reaction pH | | |
| | | | (in/hr) | | | (in/hr) | | | | (in/hr) | | (inches) | (inches) |
| Wapato 2/ | Alluvial flood plains | Silt loam, clay loam, silty clay loam | 0.1-0.4 | Silty clay loam | Firm, sticky and very plastic | 0.05-0.2 | 5.1-5.5 | Clay. Stream alluvium | Extremely hard, very firm, very sticky and very plastic | Less than 0.05 | 4.4-5.0 | 20.0-36.0 | 4.0-8.4 |
| Whatcom | Upland terrace | Silt loam | 0.2-0.5 | Silt loam, heavy loam, or silty clay loam | Very hard, sticky and plastic | 0.2-0.8 | 5.6-6.0 | Clay loam or clay with imbedded stone and cobbles. Glacial basal till. | Extremely hard, very sticky and very plastic | Less than 0.05 | 6.1-6.5 | 20.0-36.0 | 4.4-6.4 |
| Whidbey | Upland terrace | Gravelly sandy loam | 0.4-0.75 | Gravelly sandy loam or gravelly loamy sand | Loose, very friable | 5.0-10.0 | 5.1-6.0 | Gravelly sandy loam or very gravelly loamy sands. Strongly cemented glacial basal till. | Very hard, very strongly cemented | 0.05-0.2 | 6.1-6.5 | 20.0-30.0 | 2.8-3.5 |
| Wickersham | Upland terrace Alluvial fan | Shaly loam, shaly silt loam | 0.4-0.75 | Shaly loam | Friable firm | 2.5-5.0 | 5.6-6.0 | Shaly loam, alluvial fan material from mica schist and argillite bedrock | Friable | 2.5-5.0 | 6.1-6.5 | 36.0-48.0 | 3.5-5.7 |

Table 6. Properties of soils in Puget Sound Area. 1/ (con.)

| Soil Series or Land Types | Topographic Position | Surface Soils | | Subsoils | | | | Substrata | | | | Depth of Root Penetration | Water Holding Capacity |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Textures | Water Intake Rates | Textures | Consistence | Permeability | Reaction pH | Textures and/or Parent Material | Consistence | Permeability | Reaction pH | | |
| | | | (in/hr) | | | (in/hr) | | | | (in/hr) | | (inches) | (inches) |
| Wilkeson 2/ | Upland | Silt loam, loam | 0.2-0.5 | Silty clay loam | Firm, sticky and plastic | 0.2-0.8 | 5.1-5.5 | Silty clay and silty clay loam. Glacial clay basal till | Very hard, very sticky, very plastic | Less than 0.05 | 5.1-6.0 | 20.0-48.0 | 8.2-10.5 |
| Winston | Upland terrace | Gravelly sandy loam | 0.4-0.75 | Very gravelly sandy loam | Very friable | 2.5-5.0 | 5.6-6.0 | Very gravelly sand, high river terrace | Loose | 5.0-10.0 | 6.1-6.5 | 20.0-36.0 | 5.0-6.0 |
| Woodinville | Bottomland flood plain | Silt loam | 0.2-0.4 | Silty clay loam, silty clay and clay laminated | Firm, slightly sticky and slightly plastic | Less than 0.05 | 6.1-6.5 | Silty clay, clay and peat, laminated | Firm, slightly sticky and slightly plastic | Less than 0.05 | 6.1-6.5 | 12.0-30.0 | 5.0-8.0 |
| Woodlyn | Terrace basin | Silt loam | 0.2-0.4 | Silty clay loam on gravelly sand or sandy loam | Slightly hard to weak, iron cemented | 0.05-0.2 | 6.1-6.5 | Sands and gravelly sands. Glacial outwash. | Firm | 0.8-2.5 | 6.1-6.5 | 20.0-30.0 | 4.5-6.0 |

1/ Unadjusted measurements, 1966, for Puget Sound Area Study, based on National Cooperative Soil Survey maps.

2/ Benchmark soil. See footnote * at end of Land Capability Unit descriptions for definition.

## SUITABILITY OF SOILS FOR CROPLAND USE

Land for general farming is subject to various suitability limitations if the land resource is to be protected from deterioration. To define these limiting factors, soils have been grouped into (a) capability classes, (b) capability subclasses, and (c) land capability units; for example, Class IV, subclass ew, unit 14. Capability classes are practical groupings based on the severity and kind of limitation, and the response of the soil to treatment. Subclasses indicate limitations within the classes. Soils are further grouped into capability units to indicate management practices and safe methods of land use.

Lands classified for the purposes described were measured and tabulated by basin and watershed and the information obtained is shown on the tables which follow. Acreages given are the result of map measurements and compare favorably with totals derived by USGS for the Study Area. Since figures have not been factored, slight differences may be noted between these and other measurements.

In the Puget Sound Area, there are 3,367,704 acres outside national forests and national parks that are considered to have potential erosion and sediment production hazards, and there are 2,036,037 acres having some degree of wetness.

### DESCRIPTIONS OF GROUPINGS

**Capability Classes**

Soils are grouped broadly into eight capability classes designated by the Roman numerals I through VIII, according to the degree of severity of their permanent limitations but without considering major and unlikely reclamation or land-forming projects, as follows:

**Class I.** Soils in Class I have few or no limitations or hazards. They may be used safely for cultivated crops, pasture, range, woodland, or wildlife. No land has been tabulated in Class I in the Puget Sound Area.

**Class II.** Soils in Class II have few limitations or hazards. Simple conservation practices are needed when these soils are cultiveated. They are suited to cultivated crops, pasture, range, woodland, or wildlife.

**Class III.** Soils in Class III have more limitations and hazards than those in Class II. They require more difficult or complex conservation practices when cultivated. They are suited to cultivated crops, pasture, range, woodland, or wildlife.

**Class IV.** Soils in Class IV have greater limitations and hazards than Class III soils. Still more difficult or complex measures are needed when these soils are cultivated. They are suited to cultivated crops, pasture, range, woodland, or wildlife.

**Class V.** Soils in Class V have little or no erosion hazard but have other limitations that prevent normal tillage for cultivated crops. They are suited to pasture, range, woodland or wildlife.

**Class VI.** Soils in Class VI have severe limitations or hazards that make them generally unsuited for cultivation. They are suited largely to pasture, range, woodland or wildlife.

**Class VII.** Soils in Class VII have very severe limitations or hazards that prevent their use for cultivated crops, pasture, range, or woodland. They may be used for recreation, wildlife, or water supply.

**Class VIII.** Soils and land forms in Class VIII have limitations and hazards, that prevent their use for cultivated crops, pasture, range, or woodland. They may be used for recreation, wildlife, or water supply.

Interpretive criteria adopted in 1967 allow some lands classified herein as Capability Class VII to be reclassified as Capability Class VI lands, provided they are in woodland sites I, II, III, or IV and have a depth of more than 20 inches to bedrock.

The number of acres of land in the various capability classes is shown for Puget Sound Area basins in Table 7.

### Capability Subclasses

The capability subclasses indicate the kinds of limitations within the classes by the letters e, w, s, and c following the Roman numerals to designate conditions of erosion, wetness or other water condition, soils, and climate. The dominant, or primary, limitation is indicated by the second letter. Climatic conditions are not shown in this report, since these are minor and occur primarily in mountain valleys and meadows outside the area covered by soil survey mapping.

A summary of land conditions by capability subclass in basins of the Puget Sound Area is given in Table 8, and Table 9 gives the same information by watersheds.

### Capability Units

Land used for general farming usually is subject to some restrictions due to inherent soil conditions. To indicate to the farmer or operator of the land safe methods of use, the soils are further grouped into land capability units.

A land capability unit is a grouping of one or more individual soil mapping units having similar potentials and continuing limitations or hazards. The soils in a capability unit are sufficiently uniform to (a) produce similar kinds of cultivated crops and pasture plants with similar management practices, (b) require similar conservation treatment and management under the same kind and condition of vegetative cover, and (c) have comparable potential productivity.

The capability unit condenses and simplifies soils information for planning individual tracts of land, field by field. Capability units, with the class and subclass, furnish information about the degree of limitation, kind of conservation problems, and management practices needed.

A capability unit includes those soils that respond in like manner and with a minimum of soil loss to a given set of tillage practices and series of crops. The recommendations for the capability units are designed to insure high production under continued operation, consistent with safe use of the land under existing conditions of climate, soil, and topography.

Capability units are used primarily by agricultural planners in developing conservation farm and ranch plans.

Land capability unit descriptions and recommendations for their management are shown on page 118.

**Crop Yields by Land Capability Units.**—Crop yields for representative crops by capability units are estimated at two levels of management. The yields are based on field experience on typical soils for each capability unit, extended, where necessary, by judgment factors. These crop yields are shown in Table 11 for two levels of production.

Production at the "A" level is based on present average management. The yields, weighted by the area in the capability unit, closely agree with the production reported by the 1964 Census of Agriculture.

Production at the "B" level is regarded as the practical potential, using existing technology. At the present time, this level of production is reached only by the highest management represented by about 5 percent of the operators.

Table 7. Acres of soils by capability classes in Puget Sound Area. 1/

| River Basin | Capability Classes | | | | | | | Not Classified 2/ | Total 3/ |
|---|---|---|---|---|---|---|---|---|---|
| | II | III | IV | V | VI | VII | VIII | | |
| Nooksack-Sumas | 42,831 | 116,852 | 98,546 | 240 | 28,972 | 225,952 | 3,093 | 275,752 | 792,238 |
| Skagit-Samish | 83,012 | 45,659 | 73,135 | 39 | 68,121 | 244,700 | 8,515 | 1,389,373 | 1,912,554 |
| Stillaguamish | 20,327 | 22,819 | 30,412 | 0 | 51,230 | 130,878 | 2,659 | 175,302 | 433,627 |
| Whidbey-Camano | 5,447 | 6,229 | 62,028 | 0 | 51,439 | 3,416 | 4,376 | 0 | 132,935 |
| Snohomish | 51,627 | 46,516 | 153,679 | 911 | 126,313 | 276,653 | 5,071 | 533,820 | 1,194,590 |
| Cedar | 13,815 | 14,096 | 146,386 | 664 | 53,589 | 40,414 | 1,237 | 93,734 | 363,935 |
| Green | 25,208 | 8,676 | 93,186 | 230 | 21,585 | 58,600 | 1,214 | 131,534 | 340,233 |
| Puyallup | 26,923 | 39,834 | 128,391 | 219 | 89,004 | 162,976 | 6,862 | 304,841 | 759,050 |
| Nisqually | 6,411 | 51,354 | 83,790 | 0 | 66,580 | 154,174 | 1,236 | 91,241 | 454,786 |
| Deschutes | 7,363 | 18,160 | 54,525 | 0 | 44,419 | 42,096 | 1,015 | 13,230 | 180,808 |
| West Sound | 20,150 | 105,226 | 282,517 | 138 | 364,228 | 131,276 | 11,980 | 365,872 | 1,281,387 |
| Elwha-Dungeness | 8,424 | 30,851 | 20,940 | 0 | 12,684 | 32,474 | 2,944 | 338,296 | 446,613 |
| San Juan | 1,284 | 25,667 | 14,891 | 0 | 46,225 | 22,156 | 1,350 | 0 | 111,573 |
| TOTAL | 312,822 | 531,939 | 1,242,426 | 2,441 | 1,024,389 | 1,525,765 | 51,552 | 3,712,995 | 8,404,329 |

1/ Unadjusted measurements, 1966, for Puget Sound Area Study, based on National Cooperative Soil Survey maps. Accuracy to three significant figures.
2/ Includes national forest, national park, and major urban areas.
3/ Does not include fresh water of 152,444 acres.



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Table 8. Land conditions by capability subclasses, Puget Sound Area

(in acres) 1/

| Basin | Subclasses 2/ | | | | | | | Not Classified 3/ | Total |
|---|---|---|---|---|---|---|---|---|---|
| | ew | es | we | ws | s | se | sw | | |
| Nooksack-Sumas | 73,604 | 253,792 | 11,762 | 136,040 | 35,943 | 5,336 | 9 | 275,752 | 792,238 |
| Skagit-Samish | 59,439 | 267,771 | 0 | 150,006 | 38,870 | 4,375 | 2,720 | 1,389,373 | 1,912,554 |
| Stillaguamish | 43,244 | 135,540 | 0 | 35,414 | 39,411 | 4,516 | 200 | 175,302 | 433,627 |
| Whidbey-Camano | 64,120 | 15,782 | 0 | 20,350 | 21,385 | 10,312 | 986 | 0 | 132,935 |
| Snohomish | 164,822 | 301,683 | 0 | 91,911 | 57,209 | 43,229 | 1,916 | 533,820 | 1,194,590 |
| Cedar | 143,141 | 53,247 | 0 | 26,626 | 25,390 | 21,242 | 555 | 93,734 | 363,935 |
| Green | 71,873 | 67,430 | 1,961 | 34,717 | 23,871 | 8,847 | 0 | 131,534 | 340,233 |
| Puyallup | 80,223 | 183,743 | 17,415 | 68,077 | 75,933 | 28,818 | 0 | 304,841 | 759,050 |
| Nisqually | 40,413 | 162,669 | 35,143 | 33,483 | 64,636 | 26,354 | 847 | 91,241 | 454,786 |
| Deschutes | 18,507 | 60,314 | 0 | 21,736 | 46,797 | 16,707 | 3,517 | 13,230 | 180,808 |
| West Sound | 362,867 | 257,324 | 2,447 | 66,441 | 98,704 | 91,304 | 36,428 | 365,872 | 1,281,387 |
| Elwha-Dungeness | 44,820 | 31,819 | 0 | 20,818 | 10,860 | 0 | 0 | 338,296 | 446,613 |
| San Juan | 16,669 | 55,416 | 4,595 | 14,728 | 4,749 | 3,069 | 12,347 | 0 | 111,573 |
| Total | 1,183,742 | 1,846,530 | 73,323 | 720,347 | 543,758 | 264,109 | 59,525 | 3,712,995 | 8,404,329 |

1/ Unadjusted measurements, 1966, for Puget Sound Area Study, based on National Cooperative Soil Survey maps. Accuracy to three significant figures.

2/ Letters for subclasses denote hazards or conditions that affect land use and treatment: e - erosion; w - water; s - soil.

3/ Unclassified land, including national forest and national park land.

Table 9. Land conditions by capability classes and subclasses by watersheds
Nooksack-Sumas Basins

(in acres) [1]

| Class | Watershed Map Number | e | w | s | ew | es | we | ws | se | sw | Class Total |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Subclasses [2] | | | | | | | | | |
| CLASS II | 10-1 | | | | | | | 100 | | | 100 |
| | 10-2 | | | | | | | 35 | | | 35 |
| | 10-3 | | | 13 | | | | 3,611 | | | 3,624 |
| | 10-4 | | | | | | | 2,849 | | | 2,849 |
| | 10-5 | | | 84 | | | | 21 | | | 105 |
| | 10-6 | | | 363 | | | | 3,668 | | | 4,031 |
| | 10-7 | | | 736 | | | | 7,156 | | | 7,892 |
| | 10-8 | | | | | | | 5,509 | | | 5,509 |
| | 11-2 | | | | | | | 3,316 | | | 3,316 |
| | 11-3 | | | | | | | 11,648 | | | 11,648 |
| | 0-1 | | | 126 | | | | 255 | | | 381 |
| | 0-2 | | | | | | | 383 | | | 383 |
| | 0-3 | | | | | | | 268 | | | 268 |
| | 0-4 | | | | | | | 825 | | | 825 |
| | 0-5 | | | 713 | | | | 605 | | | 1,318 |
| | 0-6 | | | | | | | 129 | | | 129 |
| | 0-7 | | | | | | | 153 | | | 153 |
| | 0-8 | | | | | | | 246 | | | 246 |
| | 0-9 | | | | | | | 19 | | | 19 |
| | Total | | | 2,035 | | | | 40,796 | | | 42,831 |
| CLASS III | 10-1 | | | 373 | 756 | | | 1,357 | | | 2,486 |
| | 10-2 | | | | 34 | | | 431 | | | 465 |
| | 10-3 | | | 346 | 95 | | | 3,441 | | | 3,882 |
| | 10-4 | | | 416 | 384 | | 191 | 3,831 | | | 4,822 |
| | 10-5 | | | 217 | 10 | | 108 | 2,531 | | | 2,866 |
| | 10-6 | | | 3,516 | 201 | | 1,001 | 9,650 | | | 14,368 |
| | 10-7 | | | 2,310 | 585 | | 1,501 | 9,569 | | | 13,965 |
| | 10-8 | | | 99 | 719 | | 999 | 6,563 | | | 8,380 |
| | 11-1 | | | | 61 | | | 32 | | | 93 |
| | 11-2 | | | | 26 | | | 367 | | | 393 |
| | 11-3 | | | 1,796 | 277 | | 154 | 2,989 | | | 5,216 |
| | 0-1 | | | 1,435 | 845 | 215 | 2,042 | 8,100 | | | 12,637 |
| | 0-2 | | | 992 | 3,003 | 26 | 119 | 6,805 | | | 10,945 |
| | 0-3 | | | 164 | 1,452 | | 821 | 4,946 | | | 7,383 |
| | 0-4 | | | 189 | 27 | | 1,719 | 5,898 | | | 7,833 |
| | 0-5 | | | 241 | 73 | 14 | 1,429 | 3,593 | | | 5,350 |
| | 0-6 | | | | 34 | | 1,612 | 4,489 | | | 6,135 |
| | 0-7 | | | 180 | 468 | | 29 | 3,241 | | | 3,918 |
| | 0-8 | | | | 26 | | | 1,062 | | | 1,088 |
| | 0-9 | | | 173 | 2,410 | | 37 | 2,007 | | | 4,627 |
| | Total | | | 12,447 | 11,486 | 255 | 11,762 | 80,902 | | | 116,852 |
| CLASS IV | 10-1 | | | 5,843 | 211 | 1,891 | | 293 | | | 8,238 |
| | 10-2 | | | 151 | 14 | 669 | | 38 | | | 872 |
| | 10-3 | | | 694 | 359 | 3,152 | | 469 | 22 | | 4,696 |
| | 10-4 | | | 122 | 1,562 | 440 | | 391 | 300 | | 2,815 |
| | 10-5 | | | 207 | 2,322 | | | 17 | 455 | | 3,001 |
| | 10-6 | | | 1,474 | 817 | 239 | | 1,594 | 669 | 9 | 4,802 |
| | 10-7 | | | 4,210 | 5,541 | 1,564 | | 1,271 | 2,656 | | 15,242 |
| | 10-8 | | | 1,930 | 2,192 | 203 | | 250 | 290 | | 4,865 |
| | 11-1 | | | 24 | 39 | 57 | | 6 | | | 126 |
| | 11-2 | | | 134 | 806 | 218 | | 141 | 6 | | 1,305 |
| | 11-3 | | | 690 | 3,034 | 2,288 | | 1,393 | 8 | | 7,413 |
| | 0-1 | | | 871 | 2,866 | 1,827 | | 344 | 241 | | 6,149 |
| | 0-2 | | | 1,010 | 1,314 | 845 | | 226 | | | 3,395 |
| | 0-3 | | | 6 | 943 | 352 | | 9 | | | 1,310 |
| | 0-4 | | | 1,771 | 2,590 | 62 | | 455 | 252 | | 5,130 |
| | 0-5 | | | 274 | 3,405 | | | 10 | 43 | | 3,732 |
| | 0-6 | | | 465 | 7,326 | 99 | | 126 | | | 8,016 |
| | 0-7 | | | | 6,660 | 1,395 | | 135 | | | 8,190 |
| | 0-8 | | | | 4,480 | 1,322 | | 362 | | | 6,164 |
| | 0-9 | | | | 663 | 2,370 | | 24 | 28 | | 3,085 |
| | Total | | | 19,876 | 47,144 | 18,993 | | 7,554 | 4,970 | 9 | 98,546 |

Table 9. Land conditions by capability classes and subclasses by watersheds (con.)
Nooksack-Sumas Basins (con.)

(in acres) 1/

| Class | Watershed Map Number | Subclasses 2/ e | w | s | ew | es | we | ws | se | sw | Class Total |
|---|---|---|---|---|---|---|---|---|---|---|---|
| CLASS V | 10-8 | | | | | | | 114 | | | 114 |
| | 0-2 | | | | | | | 106 | | | 106 |
| | 0-5 | | | | | | | 9 | | | 9 |
| | 0-9 | | | | | | | 11 | | | 11 |
| | Total | | | | | | | 240 | | | 240 |
| CLASS VI | 10-1 | | | | 945 | 2,103 | | 1,451 | | | 4,499 |
| | 10-2 | | | | 306 | 632 | | 249 | | | 1,187 |
| | 10-3 | | | 236 | 1,539 | 1,716 | | 1,135 | 117 | | 4,743 |
| | 10-4 | | | | 537 | 67 | | 1,239 | | | 1,843 |
| | 10-5 | | | | 468 | 13 | | | | | 481 |
| | 10-6 | | | | 293 | 414 | | | | | 707 |
| | 10-7 | | | | 440 | 233 | | 26 | 235 | | 934 |
| | 10-8 | | | 81 | 502 | 49 | | | | | 632 |
| | 11-1 | | | | 38 | 10 | | | | | 48 |
| | 11-2 | | | | 567 | 36 | | | | | 603 |
| | 11-3 | | | | 1,197 | 349 | | 44 | | | 1,590 |
| | 0-1 | | | | 452 | 695 | | | | | 1,147 |
| | 0-2 | | | 577 | 92 | 301 | | | | | 970 |
| | 0-3 | | | 96 | 318 | 128 | | | | | 542 |
| | 0-4 | | | | 381 | 23 | | | | | 404 |
| | 0-5 | | | 68 | 218 | 130 | | | | | 416 |
| | 0-6 | | | | 986 | 470 | | | | | 1,456 |
| | 0-7 | | | | 2,358 | 706 | | | | | 3,064 |
| | 0-8 | | | 110 | 2,168 | 797 | | | 14 | | 3,089 |
| | 0-9 | | | 169 | | 448 | | | | | 617 |
| | Total | | | 1,337 | 13,805 | 9,320 | | 4,144 | 366 | | 28,972 |
| CLASS VII | 10-1 | | | | | 49,921 | | | | | 49,921 |
| | 10-2 | | | | | 29,425 | | | | | 29,425 |
| | 10-3 | | | | | 78,958 | | 2 | | | 78,960 |
| | 10-4 | | | | 54 | 10,757 | | | | | 10,811 |
| | 10-5 | | | | 65 | 2,244 | | | | | 2,309 |
| | 10-7 | | | | 227 | | | | | | 227 |
| | 11-1 | | | | | 4,856 | | | | | 4,856 |
| | 11-2 | | | | | 3,993 | | | | | 3,993 |
| | 11-3 | | | | 29 | 7,183 | | | | | 7,212 |
| | 0-2 | | | | | 484 | | | | | 484 |
| | 0-6 | | | | 351 | 1,102 | | | | | 1,453 |
| | 0-7 | | | | | 21,411 | | | | | 21,411 |
| | 0-8 | | | | | 11,625 | | | | | 11,625 |
| | 0-9 | | | | | 3,265 | | | | | 3,265 |
| | Total | | | | 726 | 225,224 | | 2 | | | 225,952 |
| CLASS VIII | 10-1 | | | | | | | 532 | | | 532 |
| | 10-2 | | | | | | | 204 | | | 204 |
| | 10-3 | | | | | | | 487 | | | 487 |
| | 10-4 | | | | | | | 591 | | | 591 |
| | 10-5 | | | | | | | 27 | | | 27 |
| | 10-6 | | | | | | | 6 | | | 6 |
| | 10-7 | | | | | | | 45 | | | 45 |
| | 10-8 | | | | 2 | | | 333 | | | 335 |
| | 0-2 | | | | 401 | | | 18 | | | 419 |
| | 0-5 | | | | | | | 41 | | | 41 |
| | 0-6 | | | 47 | | | | | | | 47 |
| | 0-7 | | | 87 | | | | 12 | | | 99 |
| | 0-8 | | | 114 | | | | 26 | | | 140 |
| | 0-9 | | | | 40 | | | 80 | | | 120 |
| | Total | | | 248 | 443 | | | 2,402 | | | 3,093 |
| GRAND TOTAL | | | | 35,943 | 73,604 | 253,792 | 11,762 | 136,040 | 5,336 | 9 | 516,486 |

1/ Unadjusted measurements, 1966, for Puget Sound Area Study, based on National Cooperative Soil Survey maps.

2/ Letters for subclasses denote hazards or conditions that affect land use and treatment: e - erosion; w - wetness; s - soil.

Table 9. Land conditions by capability classes and subclasses by watersheds (con.)
Skagit-Samish Basins

(in acres) 1/

| Class | Watershed Map Number | Subclasses 2/ e | w | s | ew | es | we | ws | se | sw | Class Total |
|---|---|---|---|---|---|---|---|---|---|---|---|
| CLASS II | 9-1 | | | 27 | | | | 1,513 | | | 1,540 |
| | 9-2 | | | | | | | 128 | | | 128 |
| | 9-3 | | | | | | | 10 | | | 10 |
| | 9-4 | | | 25 | | | | 55 | | | 80 |
| | 9-5 | | | | | | | 1,054 | | | 1,054 |
| | 9-6 | | | 155 | | | | 7,070 | | | 7,225 |
| | 9-7 | | | 350 | | | | 2,322 | | | 2,672 |
| | 9-8 | | | | | | | 7,735 | | | 7,735 |
| | 9-9 | | | | | | | 5,418 | | | 5,418 |
| | 9-10 | | | | | | | 8,202 | | | 8,202 |
| | 0-10 | | | 40 | | | | 1,496 | | | 1,536 |
| | 0-14 | | | 265 | | | | 19,814 | | | 20,079 |
| | 0-15 | | | | | | | 27,333 | | | 27,333 |
| | Total | | | 862 | | | | 82,150 | | | 83,012 |
| CLASS III | 9-1 | | | 796 | | 157 | | 3,633 | | | 4,586 |
| | 9-2 | | | | | | | 157 | | 28 | 185 |
| | 9-3 | | | 10 | | | | 301 | | | 311 |
| | 9-4 | | | 45 | | | | 195 | | | 240 |
| | 9-5 | | | 781 | 30 | | | 2,076 | | | 2,887 |
| | 9-6 | | | 3,043 | | 52 | | 4,027 | | 70 | 7,192 |
| | 9-7 | | | 2,295 | | | | 2,054 | | | 4,349 |
| | 9-8 | | | | | 18 | | 3,917 | | | 3,935 |
| | 9-9 | | | 176 | | 450 | | 1,870 | | 124 | 2,620 |
| | 9-10 | | | | 332 | 1,102 | | 2,835 | | 251 | 4,520 |
| | 0-10 | | | 123 | 977 | 59 | | 1,718 | | | 2,877 |
| | 0-14 | | | 1,285 | 257 | 578 | | 6,581 | | 6 | 8,707 |
| | 0-15 | | | | 4 | | | 3,246 | | | 3,250 |
| | Total | | | 8,554 | 1,600 | 2,416 | | 32,610 | | 479 | 45,659 |
| CLASS IV | 9-1 | | | 271 | 133 | 593 | | 217 | | | 1,214 |
| | 9-2 | | | | 912 | 40 | | 60 | | | 1,012 |
| | 9-3 | | | | | | | 20 | | | 20 |
| | 9-4 | | | | | 45 | | 5 | | | 50 |
| | 9-5 | | | 146 | | 10 | | 55 | 60 | | 271 |
| | 9-6 | | | 198 | 892 | 3,341 | | 625 | | | 5,056 |
| | 9-7 | | | 241 | 67 | 278 | | 1,347 | | | 1,933 |
| | 9-8 | | | | 1,327 | 6 | | 368 | | | 1,701 |
| | 9-9 | | | 11 | 8,010 | 1,601 | | 1,931 | | 343 | 11,896 |
| | 9-10 | | | 125 | 6,797 | 650 | | 1,359 | 5 | | 8,936 |
| | 0-10 | | | 449 | 9,527 | 27 | | 3,683 | 175 | 1,895 | 15,756 |
| | 0-14 | | | 535 | 10,563 | 1,410 | | 6,137 | | 3 | 18,648 |
| | 0-15 | | | 5 | 1,955 | 80 | | 4,577 | 25 | | 6,642 |
| | Total | | | 1,981 | 40,183 | 8,081 | | 20,384 | 265 | 2,241 | 73,135 |
| CLASS V | 0-10 | | | | | | | 6 | | | 6 |
| | 0-14 | | | | | | | 33 | | | 33 |
| | Total | | | | | | | 39 | | | 39 |

Table 9. Land conditions by capability classes and subclasses by watersheds (con.)
Skagit-Samish Basins (con.)

(In acres) 1/

| Class | Watershed Map Number | e | w | s | ew | es | we | ws | se | sw | Class Total |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Subclasses 2/ | | | | | | | | | |
| CLASS VI | 9-1 | | | 1,826 | | 1,178 | | 818 | 171 | | 3,993 |
| | 9-2 | | | 503 | 2,087 | 721 | | | 248 | | 3,559 |
| | 9-3 | | | 530 | | 135 | | 135 | | | 800 |
| | 9-4 | | | 2,480 | | 305 | | 1,045 | 240 | | 4,070 |
| | 9-5 | | | 5,566 | 20 | 2,689 | | 2,595 | 645 | | 11,515 |
| | 9-6 | | | 6,276 | 1,153 | 3,576 | | 577 | 798 | | 12,380 |
| | 9-7 | | | 2,853 | 773 | 1,304 | | 1,069 | 10 | | 6,009 |
| | 9-8 | | | 73 | 112 | 7 | | 369 | 63 | | 624 |
| | 9-9 | | | 165 | 4,202 | 1,564 | | 95 | 80 | | 6,106 |
| | 9-10 | | | 589 | 1,646 | 1,224 | | 94 | 899 | | 4,452 |
| | 0-10 | | | 1,141 | 1,076 | 2,643 | | 15 | 551 | | 5,426 |
| | 0-14 | | | 3,536 | 3,285 | 1,324 | | 133 | 405 | | 8,683 |
| | 0-15 | | | 113 | 47 | 195 | | 149 | | | 504 |
| | Total | | | 25,651 | 14,401 | 16,865 | | 7,094 | 4,110 | | 68,121 |
| CLASS VII | 9-1 | | | | | 16,790 | | 162 | | | 16,952 |
| | 9-2 | | | | | 17,536 | | | | | 17,536 |
| | 9-3 | | | | | 16,362 | | 75 | | | 16,437 |
| | 9-4 | | | | | 9,642 | | 65 | | | 9,707 |
| | 9-5 | | | 780 | | 17,014 | | 100 | | | 17,894 |
| | 9-6 | | | | 139 | 34,779 | | | | | 34,918 |
| | 9-7 | | | | | 59,889 | | 33 | | | 59,922 |
| | 9-8 | | | | 73 | 242 | | | | | 315 |
| | 9-9 | | | | 1,521 | 19,918 | | | | | 21,439 |
| | 9-10 | | | 325 | 280 | 5,016 | | | | | 5,621 |
| | 0-10 | | | | 98 | 12,474 | | | | | 12,572 |
| | 0-14 | | | | 640 | 30,375 | | | | | 31,015 |
| | 0-15 | | | | | 372 | | | | | 372 |
| | Total | | | 1,105 | 2,751 | 240,409 | | 435 | | | 244,700 |
| CLASS VIII | 9-1 | | | | | | | 448 | | | 448 |
| | 9-2 | | | 7 | | | | | | | 7 |
| | 9-3 | | | | | | | 115 | | | 115 |
| | 9-4 | | | | | | | 105 | | | 105 |
| | 9-5 | | | | | | | 1,018 | | | 1,018 |
| | 9-6 | | | 20 | | | | 395 | | | 415 |
| | 9-7 | | | | | | | 1,119 | | | 1,119 |
| | 9-8 | | | 5 | | | | 104 | | | 109 |
| | 9-9 | | | | | | | 98 | | | 98 |
| | 9-10 | | | | | | | 401 | | | 401 |
| | 0-10 | | | 237 | 429 | | | 450 | | | 1,116 |
| | 0-14 | | | 48 | 75 | | | 394 | | | 517 |
| | 0-15 | | | 400 | | | | 2,647 | | | 3,047 |
| | Total | | | 717 | 504 | | | 7,294 | | | 8,515 |
| GRAND TOTAL | | | | 38,870 | 59,439 | 267,771 | | 150,006 | 4,375 | 2,720 | 523,181 |

1/ Unadjusted measurements, 1966, for Puget Sound Area Study, based on National Cooperative Soil Survey maps.

2/ Letters for subclasses denote hazards or conditions that affect land use and treatment: e - erosion; w - wetness; s - soil.

Table 9. Land conditions by capability classes and subclasses by watersheds (con.)
Stillaguamish Basin

(in acres) 1/

| Class | Watershed Map Number | Subclasses 2/ e | w | s | ew | es | we | ws | se | sw | Class Total |
|---|---|---|---|---|---|---|---|---|---|---|---|
| CLASS II | 0-17 | | | | | | | 5,081 | | | 5,081 |
| | 0-18 | | | | | | | 1,301 | | | 1,301 |
| | 0-19 | | | | | | | 125 | | | 125 |
| | 0-20 | | | | | | | 1,341 | | | 1,341 |
| | 0-21 | | | | | | | 10,419 | | | 10,419 |
| | 0-22 | | | | | | | 2,060 | | | 2,060 |
| | Total | | | | | | | 20,327 | | | 20,327 |
| CLASS III | 0-17 | | | 3,790 | 110 | 30 | | 3,261 | | 70 | 7,261 |
| | 0-18 | | | 981 | 105 | 35 | | 1,303 | | | 2,424 |
| | 0-19 | | | 683 | 731 | | | 704 | | | 2,118 |
| | 0-20 | | | 165 | 545 | 2,525 | | 720 | | 130 | 4,085 |
| | 0-21 | | | 140 | 1,675 | 50 | | 2,904 | | | 4,769 |
| | 0-22 | | | | 1,525 | | | 637 | | | 2,162 |
| | Total | | | 5,759 | 4,691 | 2,640 | | 9,529 | | 200 | 22,819 |
| CLASS IV | 0-17 | | | 2,006 | 1,352 | | | 422 | 125 | | 3,905 |
| | 0-18 | | | 1,575 | 3,490 | | | 579 | | | 5,644 |
| | 0-19 | | | 995 | 315 | | | 124 | | | 1,434 |
| | 0-20 | | | 450 | 5,295 | 300 | | 715 | | | 6,760 |
| | 0-21 | | | 520 | 9,083 | | | 719 | | | 10,322 |
| | 0-22 | | | 10 | 2,302 | | | 35 | | | 2,347 |
| | Total | | | 5,556 | 21,837 | 300 | | 2,594 | 125 | | 30,412 |
| CLASS VI | 0-17 | | | 7,948 | 1,757 | 2,654 | | 280 | 1,360 | | 13,999 |
| | 0-18 | | | 6,774 | 3,220 | 898 | | 20 | 275 | | 11,187 |
| | 0-19 | | | 1,850 | 1,640 | 216 | | | 400 | | 4,106 |
| | 0-20 | | | 2,551 | 7,409 | 1,550 | | | 899 | | 12,409 |
| | 0-21 | | | 5,422 | 1,180 | 935 | | 10 | 1,327 | | 8,874 |
| | 0-22 | | | 135 | 335 | 50 | | 5 | 130 | | 655 |
| | Total | | | 24,680 | 15,541 | 6,303 | | 315 | 4,391 | | 51,230 |
| CLASS VII | 0-17 | | | 1,357 | | 56,121 | | | | | 57,478 |
| | 0-18 | | | 1,222 | | 25,716 | | | | | 26,938 |
| | 0-19 | | | 220 | | 18,692 | | | | | 18,912 |
| | 0-20 | | | | 1,175 | 23,009 | | | | | 24,184 |
| | 0-21 | | | 530 | | 2,494 | | | | | 3,024 |
| | 0-22 | | | 77 | | 265 | | | | | 342 |
| | Total | | | 3,406 | 1,175 | 126,297 | | | | | 130,878 |
| CLASS VIII | 0-17 | | | | | | | 699 | | | 699 |
| | 0-18 | | | | | | | 705 | | | 705 |
| | 0-19 | | | | | | | 125 | | | 125 |
| | 0-20 | | | 10 | | | | 20 | | | 30 |
| | 0-21 | | | | | | | 606 | | | 606 |
| | 0-22 | | | | | | | 494 | | | 494 |
| | Total | | | 10 | | | | 2,649 | | | 2,659 |
| GRAND TOTAL | | | | 39,411 | 43,244 | 135,540 | | 35,414 | 4,516 | 200 | 258,325 |

1/ Unadjusted measurements, 1966, for Puget Sound Area Study, based on National Cooperative Soil Survey maps.

2/ Letters for subclasses denote hazards or conditions that affect land use and treatment: e - erosion; w - wetness; s - soil.

Table 9. Land conditions by capability classes and subclasses by watersheds (con.)
Whidbey-Camano Islands

(in acres) 1/

| Class | Watershed Map Number | Subclasses 2/ e | w | s | ew | es | we | ws | se | sw | Class Total |
|---|---|---|---|---|---|---|---|---|---|---|---|
| CLASS II | 0-16 | | | | | | | 1,711 | | 118 | 1,829 |
| | 0-23 | | | | | | | 469 | | 22 | 491 |
| | 0-24 | | | | | | | 886 | | 511 | 1,397 |
| | 0-25 | | | | | | | 1,730 | | - | 1,730 |
| | Total | | | | | | | 4,796 | | 651 | 5,447 |
| CLASS III | 0-16 | | | | 101 | | | 3,541 | | | 3,642 |
| | 0-23 | | | | 24 | | | 1,095 | | | 1,119 |
| | 0-24 | | | | 31 | | | 454 | | | 485 |
| | 0-25 | | | | - | | | 983 | | | 983 |
| | Total | | | | 156 | | | 6,073 | | | 6,229 |
| CLASS IV | 0-16 | | | 968 | 10,946 | 514 | | 2,970 | | | 15,398 |
| | 0-23 | | | - | 10,390 | 6 | | 1,999 | 2,310 | 335 | 15,040 |
| | 0-24 | | | 563 | 12,383 | 200 | | 1,886 | 30 | | 15,062 |
| | 0-25 | | | | 16,058 | 5 | | 465 | | | 16,528 |
| | Total | | | 1,531 | 49,777 | 725 | | 7,320 | 2,340 | 335 | 62,028 |
| CLASS VI | 0-16 | | | 10,483 | 4,417 | 1,673 | | 121 | 844 | | 17,538 |
| | 0-23 | | | 300 | 2,572 | 2,658 | | 75 | 1,151 | | 6,756 |
| | 0-24 | | | 6,744 | 2,035 | 1,764 | | 241 | 565 | | 11,349 |
| | 0-25 | | | 1,652 | 3,121 | 5,546 | | 65 | 5,412 | | 15,796 |
| | Total | | | 19,179 | 12,145 | 11,641 | | 502 | 7,972 | | 51,439 |
| CLASS VII | 0-16 | | | | | 589 | | | | | 589 |
| | 0-23 | | | | | 1,026 | | | | | 1,026 |
| | 0-24 | | | | | 604 | | | | | 604 |
| | 0-25 | | | | | 1,197 | | | | | 1,197 |
| | Total | | | | | 3,416 | | | | | 3,416 |
| CLASS VIII | 0-16 | | | 614 | 654 | | | 208 | | | 1,476 |
| | 0-23 | | | 53 | 443 | | | 336 | | | 832 |
| | 0-24 | | | 8 | 461 | | | 944 | | | 1,413 |
| | 0-25 | | | | 484 | | | 171 | | | 655 |
| | Total | | | 675 | 2,042 | | | 1,659 | | | 4,376 |
| GRAND TOTAL | | | | 21,385 | 64,120 | 15,782 | | 20,350 | 10,312 | 986 | 132,935 |

1/ Unadjusted measurements, 1966, for Puget Sound Area Study, based on National Cooperative Soil Survey maps.
2/ Letters for subclasses denote hazards or conditions that affect land use and treatment: e - erosion; w - wetness; s - soil.

Table 9. Land conditions by capability classes and subclasses by watersheds (con.)
Snohomish Basin

(in acres) 1/

| Class | Watershed Map Number | Subclasses 2/ e | w | s | ew | es | we | ws | se | sw | Class Total |
|---|---|---|---|---|---|---|---|---|---|---|---|
| CLASS II | 8-1 | | | | | | | 3,033 | | | 3,033 |
| | 8-2 | | | | | | | 5,303 | | | 5,303 |
| | 8-3 | | | | | | | 901 | | | 901 |
| | 8-4 | | | | | | | 10,349 | | | 10,349 |
| | 8-5 | | | | | | | 5,196 | | | 5,196 |
| | 8a | | | 286 | | | | 18,502 | | | 18,788 |
| | 8b-1 | | | | | | | 4,256 | | | 4,256 |
| | 8b-2 | | | | | | | 942 | | | 942 |
| | 8b-4 | | | | | | | 1,585 | | | 1,585 |
| | 0-26 | | | | | | | 341 | | | 341 |
| | 0-33 | | | | | | | 933 | | | 933 |
| | Total | | | 286 | | | | 51,341 | | | 51,627 |
| CLASS III | 8-1 | | | 2,030 | 775 | 230 | | 3,336 | | 685 | 7,056 |
| | 8-2 | | | 854 | 607 | 60 | | 1,083 | | | 2,604 |
| | 8-3 | | | 20 | 140 | 310 | | 783 | | | 1,253 |
| | 8-4 | | | 30 | 861 | 50 | | 9,997 | | 60 | 10,998 |
| | 8-5 | | | | | 449 | | 1,125 | | | 1,574 |
| | 8a | | | 397 | 2,500 | | | 4,656 | | | 7,553 |
| | 8b-1 | | | 1,023 | 3,556 | | | 2,538 | | 16 | 7,133 |
| | 8b-2 | | | 30 | 390 | | | 225 | | | 645 |
| | 8b-4 | | | 70 | 3,343 | 328 | | 1,610 | | 297 | 5,648 |
| | 0-26 | | | | 30 | | | 630 | | 35 | 695 |
| | 0-33 | | | | 350 | | | 1,007 | | | 1,357 |
| | Total | | | 4,454 | 12,552 | 1,427 | | 26,990 | | 1,093 | 46,516 |
| CLASS IV | 8-1 | | | 2,800 | 22,237 | | | 382 | | 643 | 26,062 |
| | 8-2 | | | 919 | 2,804 | | | 506 | | | 4,229 |
| | 8-3 | | | 435 | 2,586 | | | 20 | | | 3,041 |
| | 8-4 | | | 440 | 14,838 | | | 820 | | | 16,098 |
| | 8-5 | | | 61 | 5,263 | | | 152 | | | 5,476 |
| | 8a | | | 8,608 | 39,288 | 4,946 | | 1,266 | 2,212 | | 56,320 |
| | 8b-1 | | | 1,404 | 1,020 | | | 170 | | | 2,594 |
| | 8b-2 | | | 187 | 568 | | | | | | 755 |
| | 8b-4 | | | 1,271 | 7,676 | | | 160 | | | 9,107 |
| | 0-26 | | | 350 | 11,945 | | | 48 | | 50 | 12,393 |
| | 0-33 | | | 214 | 17,190 | | | 70 | | 130 | 17,604 |
| | Total | | | 16,689 | 125,415 | 4,946 | | 3,594 | 2,212 | 823 | 153,679 |
| CLASS V | 8a | | | | | | | 911 | | | 911 |
| | Total | | | | | | | 911 | | | 911 |
| CLASS VI | 8-1 | | | 2,998 | 3,073 | 3,828 | | 35 | 6,338 | | 16,272 |
| | 8-2 | | | 624 | 651 | 2,169 | | 25 | 845 | | 4,314 |
| | 8-3 | | | 130 | 718 | 277 | | 65 | 1,202 | | 2,392 |
| | 8-4 | | | 7,115 | 1,815 | 400 | | 65 | 1,531 | | 10,926 |
| | 8-5 | | | 150 | 282 | 567 | | 70 | 1,048 | | 2,117 |
| | 8a | | | 6,162 | 10,670 | 3,295 | | 1,878 | 18,405 | | 40,410 |
| | 8b-1 | | | 6,752 | 2,130 | 1,056 | | 1,958 | 360 | | 12,256 |
| | 8b-2 | | | 3,543 | 338 | 2,695 | | | 2,434 | | 9,010 |
| | 8b-4 | | | 4,155 | 2,639 | 5,458 | | | 3,947 | | 16,199 |
| | 0-26 | | | 664 | 2,414 | 1,525 | | | 2,084 | | 6,687 |
| | 0-33 | | | 752 | 1,836 | 319 | | | 2,823 | | 5,730 |
| | Total | | | 33,045 | 26,566 | 21,589 | | 4,096 | 41,017 | | 126,313 |

Table 9. Land conditions by capability classes and subclasses by watersheds (con.)
Snohomish Basin (con.)

(in acres) 1/

| Class | Watershed Map Number | e | w | s | ew | es | we | ws | se | sw | Class Total |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Subclasses 2/ | | | | | | | | | |
| CLASS VII | 8-1 | | | 725 | | 19,485 | | | | | 20,210 |
| | 8-2 | | | | | 1,382 | | | | | 1,382 |
| | 8-3 | | | | | 1,200 | | | | | 1,200 |
| | 8-4 | | | | | 858 | | | | | 858 |
| | 8-5 | | | | | 557 | | | | | 557 |
| | 8a | | | | | 147,556 | | | | | 147,556 |
| | 8b-1 | | | 1,205 | | 56,781 | | 502 | | | 58,488 |
| | 8b-2 | | | 65 | | 34,319 | | | | | 34,384 |
| | 8b-4 | | | 435 | | 7,016 | | | | | 7,451 |
| | 0-26 | | | | | 4,002 | | | | | 4,002 |
| | 0-33 | | | | | 565 | | | | | 565 |
| | Total | | | 2,430 | | 273,721 | | 502 | | | 276,653 |
| CLASS VIII | 8-1 | | | | | | | 410 | | | 410 |
| | 8-2 | | | | | | | 43 | | | 43 |
| | 8-3 | | | | | | | 110 | | | 110 |
| | 8-4 | | | 290 | 10 | | | 693 | | | 993 |
| | 8-5 | | | | | | | 43 | | | 43 |
| | 8a | | | | | | | 1,699 | | | 1,699 |
| | 8b-1 | | | | | | | 1,056 | | | 1,056 |
| | 8b-2 | | | | | | | 28 | | | 28 |
| | 8b-4 | | | | | | | 73 | | | 73 |
| | 0-26 | | | 15 | 209 | | | 144 | | | 368 |
| | 0-33 | | | | 70 | | | 178 | | | 248 |
| | Total | | | 305 | 289 | | | 4,477 | | | 5,071 |
| GRAND TOTAL | | | | 57,209 | 164,822 | 301,683 | | 91,911 | 43,229 | 1,916 | 660,770 |

1/ Unadjusted measurements, 1966, for Puget Sound Area Study, based on National Cooperative Soil Survey maps.
2/ Letters for subclasses denote hazards or conditions that affect land use and treatment: e - erosion; w - wetness; s - soil.

Table 9. Land conditions by capability classes and subclasses by watersheds (con.)
Cedar Basin

(in acres) 1/

| Class | Watershed Map Number | e | w | s | ew | es | we | ws | se | sw | Class Total |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Subclasses 2/ | | | | | | | | | |
| CLASS II | 0-27 | | | | | | | 2,256 | | | 2,256 |
| | 0-28 | | | | | | | 2,612 | | | 2,612 |
| | 0-29 | | | | | | | 42 | | | 42 |
| | 0-30 | | | | | | | 6,997 | | | 6,997 |
| | 0-31 | | | | | | | 1,908 | | | 1,908 |
| | Total | | | | | | | 13,815 | | | 13,815 |
| CLASS III | 0-27 | | | 15 | 227 | | | 3,011 | | 75 | 3,328 |
| | 0-28 | | | | 2,776 | | | 1,233 | | 15 | 4,024 |
| | 0-29 | | | | 512 | | | 81 | | | 593 |
| | 0-30 | | | 15 | 3,165 | | | 2,069 | | 165 | 5,414 |
| | 0-31 | | | | 479 | | | 258 | | | 737 |
| | Total | | | 30 | 7,159 | | | 6,652 | | 255 | 14,096 |
| CLASS IV | 0-27 | | | 35 | 25,733 | | | 970 | 261 | 135 | 27,134 |
| | 0-28 | | | 199 | 34,824 | 748 | | 918 | 4,368 | | 41,057 |
| | 0-29 | | | | 2,619 | | | 33 | 60 | | 2,712 |
| | 0-30 | | | 5,046 | 37,994 | 653 | | 1,021 | 1,287 | 165 | 46,166 |
| | 0-31 | | | 11,627 | 16,535 | 502 | | 396 | 257 | | 29,317 |
| | Total | | | 16,907 | 117,705 | 1,903 | | 3,338 | 6,233 | 300 | 146,386 |
| CLASS V | 0-27 | | | | | | | | | | - |
| | 0-28 | | | | | | | 86 | | | 86 |
| | 0-29 | | | | | | | | | | - |
| | 0-30 | | | | | | | 492 | | | 492 |
| | 0-31 | | | | | | | 86 | | | 86 |
| | Total | | | | | | | 664 | | | 664 |
| CLASS VI | 0-27 | | | 1,478 | 3,261 | 1,409 | | | 5,623 | | 11,771 |
| | 0-28 | | | 1,900 | 6,406 | 2,452 | | 206 | 3,633 | | 14,597 |
| | 0-29 | | | 139 | 1,000 | 713 | | | 465 | | 2,317 |
| | 0-30 | | | 3,919 | 6,420 | 3,133 | | 190 | 4,486 | | 18,148 |
| | 0-31 | | | 839 | 1,025 | 3,223 | | 867 | 802 | | 6,756 |
| | Total | | | 8,275 | 18,112 | 10,930 | | 1,263 | 15,009 | | 53,589 |
| CLASS VII | 0-27 | | | | | 200 | | | | | 200 |
| | 0-28 | | | | | 6,184 | | | | | 6,184 |
| | 0-29 | | | | | 56 | | | | | 56 |
| | 0-30 | | | | | 23,981 | | | | | 23,981 |
| | 0-31 | | | | | 9,993 | | | | | 9,993 |
| | Total | | | | | 40,414 | | | | | 40,414 |
| CLASS VIII | 0-27 | | | | | | | 106 | | | 106 |
| | 0-28 | | | 121 | 30 | | | 134 | | | 285 |
| | 0-29 | | | 1 | 47 | | | | | | 48 |
| | 0-30 | | | 11 | 88 | | | 216 | | | 315 |
| | 0-31 | | | 45 | | | | 438 | | | 483 |
| | Total | | | 178 | 165 | | | 894 | | | 1,237 |
| GRAND TOTAL | | | | 25,390 | 143,141 | 53,247 | | 26,626 | 21,242 | 555 | 270,201 |

1/ Unadjusted measurements, 1966, for Puget Sound Area Study, based on National Cooperative Soil Survey maps.
2/ Letters for subclasses denote hazards or conditions that affect land use and treatment: e - erosion; w - wetness; s - soil.

AD-A037 582 PACIFIC NORTHWEST RIVER BASINS COMMISSION VANCOUVER WASH F/G 8/6
COMPREHENSIVE STUDY OF WATER AND RELATED LAND RESOURCES. PUGET --ETC(U)
MAR 70 A T NEALE, S STEINBORN, L F KEHNE

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Table 9. Land conditions by capability classes and subclasses by watersheds (con.)
Green Basin

(in acres) 1/

| Class | Watershed Map Number | e | w | s | ew | es | we | ws | se | sw | Class Total |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Subclasses 2/ | | | | | | | | | |
| CLASS II | 0-29 | | | | | | | 114 | | | 114 |
| | 0-34 | | | | | | | 11,752 | | | 11,752 |
| | 0-35 | | | | | | | 10,695 | | | 10,695 |
| | 0-36 | | | | | | | 172 | | | 172 |
| | 0-37 | | | | | | | 2,475 | | | 2,475 |
| | Total | | | | | | | 25,208 | | | 25,208 |
| CLASS II | 0-29 | | | | 279 | | | 127 | | | 406 |
| | 0-34 | | | | 48 | | | 1,006 | | | 1,054 |
| | 0-35 | | | | 21 | | 395 | 1,029 | | | 1,445 |
| | 0-36 | | | | 228 | | | 123 | | | 351 |
| | 0-37 | | | | 15 | | 1,566 | 3,839 | | | 5,420 |
| | Total | | | | 591 | | 1,961 | 6,124 | | | 8,676 |
| CLASS IV | 0-29 | | | | 6,220 | | | | 701 | | 6,921 |
| | 0-34 | | | 8,064 | 31,207 | 1,076 | | 450 | 306 | | 41,103 |
| | 0-35 | | | | 10,813 | 479 | | 261 | 274 | | 11,827 |
| | 0-36 | | | | 11,845 | | | 80 | 658 | | 12,583 |
| | 0-37 | | | 9,932 | 6,336 | 3,664 | | 368 | 452 | | 20,752 |
| | Total | | | 17,996 | 66,421 | 5,219 | | 1,159 | 2,391 | | 93,186 |
| CLASS V | 0-34 | | | | | | | 97 | | | 97 |
| | 0-35 | | | | | | | 89 | | | 89 |
| | 0-37 | | | | | | | 44 | | | 44 |
| | Total | | | | | | | 230 | | | 230 |
| CLASS VI | 0-29 | | | 183 | 276 | 24 | | | 956 | | 1,439 |
| | 0-34 | | | 4,499 | 2,524 | 1,789 | | 485 | 3,538 | | 12,835 |
| | 0-35 | | | 319 | 379 | 323 | | 575 | 435 | | 2,031 |
| | 0-36 | | | 364 | 1,239 | 45 | | | 595 | | 2,243 |
| | 0-37 | | | 222 | 356 | 1,430 | | 97 | 932 | | 3,037 |
| | Total | | | 5,587 | 4,774 | 3,611 | | 1,157 | 6,456 | | 21,585 |
| CLASS VII | 0-29 | | | | | 1,065 | | | | | 1,065 |
| | 0-34 | | | | | 3,415 | | | | | 3,415 |
| | 0-35 | | | | | 2,960 | | | | | 2,960 |
| | 0-36 | | | | | 1,184 | | | | | 1,184 |
| | 0-37 | | | | | 49,976 | | | | | 49,976 |
| | Total | | | | | 58,600 | | | | | 58,600 |
| CLASS VIII | 0-29 | | | | 43 | | | 64 | | | 107 |
| | 0-34 | | | 77 | 12 | | | 363 | | | 452 |
| | 0-35 | | | 25 | 15 | | | 274 | | | 314 |
| | 0-36 | | | | 17 | | | | | | 17 |
| | 0-37 | | | 186 | | | | 138 | | | 324 |
| | Total | | | 288 | 87 | | | 839 | | | 1,214 |
| GRAND TOTAL | | | | 23,871 | 71,873 | 67,430 | 1,961 | 34,717 | 8,847 | | 208,699 |

1/ Unadjusted measurements, 1966, for Puget Sound Area Study, based on National Cooperative Soil Survey maps.

2/ Letters for subclasses denote hazards or conditions that affect land use and treatment: e - erosion; w - wetness; s - soil.

Table 9. Land conditions by capability classes and subclasses by watersheds (con.)
Puyallup Basin

(in acres) 1/

| Class | Watershed Map Number | e | w | s | ew | es | we | ws | se | sw | Class Total |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Subclasses 2/ | | | | | | | | | |
| CLASS II | 7-1 | | | | | | | 6,382 | | | 6,382 |
| | 7-2 | | | | | | | 1,402 | | | 1,402 |
| | 7-3 | | | | | | | 10,352 | | | 10,352 |
| | 7-4 | | | | | | | 284 | | | 284 |
| | 0-38 | | | | | | | 1,668 | | | 1,668 |
| | 0-39 | | | | | | | 2,394 | | | 2,394 |
| | 0-40 | | | | | | | 4,441 | | | 4,441 |
| | Total | | | | | | | 26,923 | | | 26,923 |
| CLASS III | 7-1 | | | | 33 | | 3,203 | 13,917 | | | 17,153 |
| | 7-2 | | | | | | | 200 | | | 200 |
| | 7-3 | | | | 780 | | 7,848 | 2,449 | | | 11,077 |
| | 7-4 | | | | 100 | | 227 | 2,875 | | | 3,202 |
| | 0-38 | | | | 502 | | 334 | 158 | | | 994 |
| | 0-39 | | | | | | 444 | 24 | | | 468 |
| | 0-40 | | | | 762 | | 5,359 | 619 | | | 6,740 |
| | Total | | | | 2,177 | | 17,415 | 20,242 | | | 39,834 |
| CLASS IV | 7-1 | | | 1,049 | 12,428 | 35 | | 1,549 | 415 | | 15,476 |
| | 7-2 | | | 1,539 | 4,286 | | | 306 | 689 | | 6,820 |
| | 7-3 | | | 407 | 15,630 | | | 4,070 | 2,902 | | 23,009 |
| | 7-4 | | | 211 | 2,984 | | | 222 | 510 | | 3,927 |
| | 0-38 | | | 1 | 8,998 | | | 714 | 223 | | 9,936 |
| | 0-39 | | | | 1,050 | | | 921 | | | 1,971 |
| | 0-40 | | | 46,313 | 19,110 | | | 1,614 | 215 | | 67,252 |
| | Total | | | 49,520 | 64,486 | 35 | | 9,396 | 4,954 | | 128,391 |
| CLASS V | 7-1 | | | | | | | 219 | | | 219 |
| | Total | | | | | | | 219 | | | 219 |
| CLASS VI | 7-1 | | | 4,749 | 3,891 | 599 | | 2,880 | 3,647 | | 15,766 |
| | 7-2 | | | 65 | 1,800 | 5,977 | | 393 | 2,198 | | 10,433 |
| | 7-3 | | | 8,986 | 2,308 | 6,936 | | 1,796 | 7,328 | | 27,354 |
| | 7-4 | | | 650 | 2,248 | 3,373 | | 150 | 2,955 | | 9,376 |
| | 0-38 | | | 291 | 398 | 300 | | 12 | 597 | | 1,598 |
| | 0-39 | | | | 209 | 54 | | | 115 | | 378 |
| | 0-40 | | | 9,661 | 2,592 | 4,806 | | 16 | 7,024 | | 24,099 |
| | Total | | | 24,402 | 13,446 | 22,045 | | 5,247 | 23,864 | | 89,004 |
| CLASS VII | 7-1 | | | | | 65,342 | | 396 | | | 65,738 |
| | 7-2 | | | | | 22,641 | | 402 | | | 23,043 |
| | 7-3 | | | | | 43,504 | | 410 | | | 43,914 |
| | 7-4 | | | | | 21,854 | | 60 | | | 21,914 |
| | 0-38 | | | | | 1,508 | | | | | 1,508 |
| | 0-39 | | | | | 516 | | | | | 516 |
| | 0-40 | | | | | 6,298 | | 45 | | | 6,343 |
| | Total | | | | | 161,663 | | 1,313 | | | 162,976 |
| CLASS VIII | 7-1 | | | 68 | | | | 2,640 | | | 2,708 |
| | 7-2 | | | 33 | | | | 574 | | | 607 |
| | 7-3 | | | 150 | | | | 996 | | | 1,146 |
| | 7-4 | | | 175 | | | | 10 | | | 185 |
| | 0-38 | | | 240 | 5 | | | 51 | | | 296 |
| | 0-39 | | | 348 | | | | 332 | | | 680 |
| | 0-40 | | | 997 | 109 | | | 134 | | | 1,240 |
| | Total | | | 2,011 | 114 | | | 4,737 | | | 6,862 |
| GRAND TOTAL | | | | 75,933 | 80,223 | 183,743 | 17,415 | 68,077 | 28,818 | | 454,209 |

1/ Unadjusted measurements, 1966, for Puget Sound Area Study, based on National Cooperative Soil Survey maps.
2/ Letters for subclasses denote hazards or conditions that affect land use and treatment: e - erosion; w - wetness; s - soil.

Table 9. Land conditions by capability classes and subclasses by watersheds (con.)
Nisqually Basin

(in acres) 1/

| Class | Watershed Map Number | Subclasses 2/ e | w | s | ew | es | we | ws | se | sw | Class Total |
|---|---|---|---|---|---|---|---|---|---|---|---|
| CLASS II | 0-41 | | | | | | | 1,898 | | | 1,898 |
| | 0-42 | | | | | | | 1,108 | | | 1,108 |
| | 0-43 | | | | | | | 302 | | | 302 |
| | 0-44 | | | | | | | 180 | | | 180 |
| | 0-45 | | | 596 | | | | 2,327 | | | 2,923 |
| | Total | | | 596 | | | | 5,815 | | | 6,411 |
| CLASS III | 0-41 | | | | 149 | | 16,590 | 1,821 | | | 18,560 |
| | 0-42 | | | | 8 | | 14,698 | 970 | | | 15,676 |
| | 0-43 | | | | | | 3,232 | 651 | | | 3,883 |
| | 0-44 | | | | | | 585 | 21 | | | 606 |
| | 0-45 | | | 1,059 | 676 | 40 | 38 | 10,816 | | | 12,629 |
| | Total | | | 1,059 | 833 | 40 | 35,143 | 14,279 | | | 51,354 |
| CLASS IV | 0-41 | | | 23,955 | 3,354 | | | 2,696 | 654 | | 30,659 |
| | 0-42 | | | 82 | 863 | | | 1,651 | 348 | | 2,944 |
| | 0-43 | | | 65 | 4,124 | | | 343 | 5 | | 4,537 |
| | 0-44 | | | 5 | 7,797 | | | 227 | | | 8,029 |
| | 0-45 | | | 16,023 | 14,159 | 1,848 | | 3,821 | 923 | 847 | 37,621 |
| | Total | | | 40,130 | 30,297 | 1,848 | | 8,738 | 1,930 | 847 | 83,790 |
| CLASS VI | 0-41 | | | 5,549 | 254 | 1,539 | | 34 | 10,532 | | 17,908 |
| | 0-42 | | | 1,871 | 1,928 | 542 | | 743 | 2,580 | | 7,664 |
| | 0-43 | | | 482 | 1,364 | 834 | | | 1,043 | | 3,723 |
| | 0-44 | | | 404 | 3,065 | 180 | | 90 | 940 | | 4,679 |
| | 0-45 | | | 12,896 | 2,672 | 5,533 | | 2,176 | 9,329 | | 32,606 |
| | Total | | | 21,202 | 9,283 | 8,628 | | 3,043 | 24,424 | | 66,560 |
| CLASS VII | 0-41 | | | | | 1,507 | | | | | 1,507 |
| | 0-42 | | | | | 6,331 | | | | | 6,331 |
| | 0-43 | | | | | 15,145 | | 10 | | | 15,155 |
| | 0-44 | | | | | 40,687 | | 2 | | | 40,689 |
| | 0-45 | | | 1,649 | | 88,483 | | 360 | | | 90,492 |
| | Total | | | 1,649 | | 152,153 | | 372 | | | 154,174 |
| CLASS VIII | 0-42 | | | | | | | 83 | | | 83 |
| | 0-43 | | | | | | | 4 | | | 4 |
| | 0-44 | | | | | | | 17 | | | 17 |
| | 0-45 | | | | | | | 1,132 | | | 1,132 |
| | Total | | | | | | | 1,236 | | | 1,236 |
| GRAND TOTAL | | | | 64,636 | 40,413 | 162,669 | 35,143 | 33,483 | 26,354 | 847 | 363,545 |

1/ Unadjusted measurements, 1966, for Puget Sound Area Study, based on National Cooperative Soil Survey maps.

2/ Letters for subclasses denote hazards or conditions that affect land use and treatment: e - erosion; w - wetness; s - soil.

Table 9. Land conditions by capability classes and subclasses by watersheds (con.)
Deschutes Basin

(in acres) 1/

| Class | Watershed Map Number | e | w | s | ew | es | we | ws | se | sw | Class Total |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Subclasses 2/ | | | | | | | | | |
| CLASS II | 0-46 | | | | | | | 3,098 | | | 3,098 |
| | 0-47 | | | | | | | 3,172 | | | 3,172 |
| | 0-48 | | | | | | | 1,093 | | | 1,093 |
| | Total | | | | | | | 7,363 | | | 7,363 |
| CLASS III | 0-46 | | | 2,996 | | 15 | | 2,991 | | | 6,002 |
| | 0-47 | | | 2,978 | | | | 6,588 | | | 9,566 |
| | 0-48 | | | 1,154 | | 40 | | 1,338 | | 60 | 2,592 |
| | Total | | | 7,128 | | 55 | | 10,917 | | 60 | 18,160 |
| CLASS IV | 0-46 | | | 14,352 | 2,816 | 1,773 | | 1,539 | 1,632 | 949 | 23,061 |
| | 0-47 | | | 9,568 | 8,082 | 2,926 | | 854 | 2,162 | 1,612 | 25,204 |
| | 0-48 | | | 640 | 3,029 | 1,053 | | 398 | 244 | 896 | 6,260 |
| | Total | | | 24,560 | 13,927 | 5,752 | | 2,791 | 4,038 | 3,457 | 54,525 |
| CLASS VI | 0-46 | | | 4,609 | 591 | 5,708 | | | 3,390 | | 14,298 |
| | 0-47 | | | 7,386 | 2,170 | 5,614 | | | 7,155 | | 22,325 |
| | 0-48 | | | 1,826 | 824 | 3,022 | | | 2,124 | | 7,796 |
| | Total | | | 13,821 | 3,585 | 14,344 | | | 12,669 | | 44,419 |
| CLASS VII | 0-46 | | | 938 | 63 | 35,228 | | | | | 36,229 |
| | 0-47 | | | | 616 | 826 | | | | | 1,442 |
| | 0-48 | | | | 316 | 4,109 | | | | | 4,425 |
| | Total | | | 938 | 995 | 40,163 | | | | | 42,096 |
| CLASS VIII | 0-46 | | | | | | | 130 | | | 130 |
| | 0-47 | | | 310 | | | | 485 | | | 795 |
| | 0-48 | | | 40 | | | | 50 | | | 90 |
| | Total | | | 350 | | | | 665 | | | 1,015 |
| GRAND TOTAL | | | | 46,797 | 18,507 | 60,314 | | 21,736 | 16,707 | 3,517 | 167,578 |

1/ Unadjusted measurements, 1966, for Puget Sound Area Study, based on National Cooperative Soil Survey maps.

2/ Letters for subclasses denote hazards or conditions that affect land use and treatment: e - erosion; w - wetness; s - soil.

Table 9. *Land conditions by capability classes and subclasses by watersheds (con.)*
West Sound Basins

(in acres) 1/

| Class | Watershed Map Number | e | w | s | ew | es | we | ws | se | sw | Class Total |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Subclasses 2/ | | | | | | | | | |
| CLASS II | 0-49 | | | | | | | 947 | | | 947 |
| | 0-50 | | | | | | | 681 | | | 681 |
| | 0-52 | | | | | | | 55 | | | 55 |
| | 0-53 | | | | | | | 66 | | | 66 |
| | 0-54 | | | | | | | 932 | | | 932 |
| | 0-55 | | | | | | | 2,522 | | | 2,522 |
| | 0-56 | | | | | | | 4,352 | | | 4,352 |
| | 0-57 | | | | | | | 413 | | | 413 |
| | 0-58 | | | | | | | 700 | | | 700 |
| | 0-59 | | | | | | | 89 | | | 89 |
| | 0-60 | | | | | | | 488 | | | 488 |
| | 0-62 | | | | | | | 611 | | | 611 |
| | 0-66 | | | | | | | 115 | | | 115 |
| | 0-67 | | | | | | | 390 | | 18 | 408 |
| | 0-68 | | | | | | | 129 | | | 129 |
| | 0-69 | | | | | | | 315 | | | 315 |
| | 0-70 | | | | | | | 1,113 | | | 1,113 |
| | 0-71 | | | | | | | 940 | | 31 | 971 |
| | 0-72 | | | | | | | 1,762 | | 1,120 | 2,882 |
| | 0-73 | | | | | | | 1,584 | | 451 | 2,035 |
| | 0-75 | | | | | | | 134 | | 45 | 179 |
| | 0-76 | | | | | | | 147 | | | 147 |
| | Total | | | | | | | 18,485 | | 1,665 | 20,150 |
| CLASS III | 0-49 | | | 830 | | 2,191 | | 3,133 | | 717 | 6,871 |
| | 0-50 | | | | | 459 | | 785 | | 60 | 1,304 |
| | 0-51 | | | | | | 196 | 65 | | | 261 |
| | 0-52 | | | | | | 322 | 257 | | | 579 |
| | 0-53 | | | | | | | 246 | | | 246 |
| | 0-54 | | | | | | | 1,280 | | 355 | 1,635 |
| | 0-55 | | | | 2,570 | | | 1,961 | | | 4,531 |
| | 0-56 | | | | | | | 172 | | | 172 |
| | 0-57 | | | | | | | 110 | | | 110 |
| | 0-58 | | | | | | | 25 | | | 25 |
| | 0-59 | | | | 2,837 | | | 1,031 | | | 3,868 |
| | 0-60 | | | | 926 | | | 890 | | | 1,816 |
| | 0-62 | | | | 2,471 | | 1,919 | 2,050 | | | 6,440 |
| | 0-63 | | | | 220 | | | 89 | | | 309 |
| | 0-66 | | | | | | | 15 | | | 15 |
| | 0-67 | | | | | | | 406 | | | 406 |
| | 0-68 | | | | 12,335 | | | 1,230 | | | 13,565 |
| | 0-69 | | | | 12,537 | | | 3,766 | | | 16,303 |
| | 0-70 | | | | 20,276 | | | 2,869 | | | 23,145 |
| | 0-71 | | | | | 261 | | 1,038 | | | 1,299 |
| | 0-72 | | | | 2,623 | 479 | | 2,149 | | | 5,251 |
| | 0-73 | | | | 295 | 81 | | 1,115 | | | 1,491 |
| | 0-75 | | | | 8,756 | | | 173 | | | 8,929 |
| | 0-76 | | | | 5,253 | | | 1,402 | | | 6,655 |
| | Total | | | 830 | 71,099 | 3,471 | 2,437 | 26,257 | | 1,132 | 105,226 |

Table 9. Land conditions by capability classes and subclasses by watersheds (con.)
West Sound Basins (con.)

(in acres) 1/

| Class | Watershed Map Number | Subclasses 2/ e | w | s | ew | es | we | ws | se | sw | Class Total |
|---|---|---|---|---|---|---|---|---|---|---|---|
| CLASS IV | 0-49 | | | 258 | 7,142 | 6,864 | 10 | 425 | 179 | 802 | 15,680 |
| | 0-50 | | | 30 | 4,312 | 4,195 | | 207 | 105 | | 8,849 |
| | 0-51 | | | | 2,140 | | | 712 | 10 | | 2,862 |
| | 0-52 | | | | 2,177 | | | | 522 | | 2,699 |
| | 0-53 | | | 1 | 3,131 | | | 328 | 253 | 325 | 4,038 |
| | 0-54 | | | 79 | 1,094 | 11,421 | | 983 | | | 13,577 |
| | 0-55 | | | 297 | 54,323 | 495 | | 992 | 1,026 | | 57,133 |
| | 0-56 | | | 63 | 2,113 | 1,644 | | 450 | | | 4,270 |
| | 0-57 | | | 221 | | 125 | | 57 | | | 403 |
| | 0-58 | | | 50 | 7 | 485 | | 129 | | 5 | 676 |
| | 0-59 | | | 45 | 12,232 | | | 142 | 145 | | 12,564 |
| | 0-60 | | | | 11,119 | 335 | | 235 | 1,090 | | 12,779 |
| | 0-62 | | | 6 | 22,300 | | | 553 | 3,544 | | 26,403 |
| | 0-63 | | | | 15,758 | | | 30 | 335 | | 16,123 |
| | 0-66 | | | | 25 | | | | | | 25 |
| | 0-67 | | | | 20 | | | 23 | 95 | | 138 |
| | 0-68 | | | 5 | 10,805 | 8 | | 134 | 55 | | 11,007 |
| | 0-69 | | | 205 | 16,818 | 90 | | 1,392 | | | 18,505 |
| | 0-70 | | | 1,134 | 13,953 | 222 | | 2,221 | | | 17,530 |
| | 0-71 | | | | 1,776 | | | 615 | 16 | 1,985 | 4,392 |
| | 0-72 | | | 193 | 13,863 | 63 | | 2,203 | 557 | 25,877 | 42,756 |
| | 0-73 | | | 58 | 2,709 | | | 857 | | 4,637 | 8,261 |
| | 0-75 | | | 480 | 298 | | | 122 | | | 900 |
| | 0-76 | | | 257 | 35 | | | 655 | | | 947 |
| | Total | | | 3,382 | 198,150 | 25,947 | 10 | 13,465 | 7,932 | 33,631 | 282,517 |
| CLASS V | 0-63 | | | | | | | 11 | | | 11 |
| | 0-67 | | | | | | | 5 | | | 5 |
| | 0-72 | | | | | | | 122 | | | 122 |
| | Total | | | | | | | 138 | | | 138 |
| CLASS VI | 0-49 | | | 1,103 | 3,451 | 3,420 | | 60 | 2,411 | | 10,445 |
| | 0-50 | | | 580 | 716 | 2,591 | | | 1,965 | | 5,852 |
| | 0-51 | | | 742 | | 135 | | | 775 | | 1,652 |
| | 0-52 | | | | 219 | 355 | | | 215 | | 789 |
| | 0-53 | | | 1,130 | 252 | 7,416 | | | | | 8,798 |
| | 0-54 | | | 11,300 | | 5,165 | | 175 | 3,233 | | 19,873 |
| | 0-55 | | | 8,461 | 5,600 | 4,105 | | 42 | 16,545 | | 34,753 |
| | 0-56 | | | 1,895 | 129 | 2,870 | | 500 | 948 | | 6,342 |
| | 0-57 | | | 715 | | 6,320 | | 175 | 1,075 | | 8,285 |
| | 0-58 | | | 1,325 | | 13,158 | | 185 | 1,461 | | 16,129 |
| | 0-59 | | | 1,855 | 1,332 | 1,083 | | 479 | 3,272 | | 8,021 |
| | 0-60 | | | 3,214 | 1,002 | 5,152 | | 82 | 4,324 | | 13,774 |
| | 0-62 | | | 15,305 | 5,605 | 6,953 | | | 14,498 | | 42,361 |
| | 0-63 | | | 145 | 773 | 87 | | | 465 | | 1,470 |
| | 0-66 | | | 340 | | 1,260 | | | 45 | | 1,645 |
| | 0-67 | | | 506 | 7 | 9,482 | | | 49 | | 10,044 |
| | 0-68 | | | 1,971 | 2,793 | 7,574 | | 234 | 9,299 | | 21,871 |
| | 0-69 | | | 10,468 | 11,486 | 4,871 | | | 8,737 | | 35,562 |
| | 0-70 | | | 23,161 | 9,940 | 5,548 | | | 9,573 | | 48,222 |
| | 0-71 | | | 752 | 3,299 | 6,354 | | | | | 10,405 |
| | 0-72 | | | 6,676 | 18,899 | 17,639 | | | 4,271 | | 47,485 |
| | 0-73 | | | 1,859 | 5,192 | 2,000 | | | 186 | | 9,237 |
| | 0-75 | | | 140 | 580 | 205 | | | 25 | | 950 |
| | 0-76 | | | 40 | 223 | | | | | | 263 |
| | Total | | | 93,683 | 71,498 | 113,743 | | 1,932 | 83,372 | | 364,228 |

Table 9. Land conditions by capability classes and subclasses by watersheds (con.)
West Sound Basins (con.)

(in acres) 1/

| Class | Watershed Map Number | e | w | s | ew | es | we | ws | se | sw | Class Total |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Subclasses 2/ | | | | | | | | | |
| CLASS VII | 0-49 | | | | 64 | 20,239 | | | | | 20,303 |
| | 0-50 | | | | | 5,156 | | | | | 5,156 |
| | 0-51 | | | | | 252 | | | | | 252 |
| | 0-52 | | | | | 95 | | | | | 95 |
| | 0-53 | | | | | 388 | | | | | 388 |
| | 0-54 | | | | | 2,359 | | | | | 2,359 |
| | 0-55 | | | | 1,577 | 1,206 | | | | | 2,783 |
| | 0-56 | | | | 820 | 7,592 | | 142 | | | 8,554 |
| | 0-57 | | | | | 7,457 | | 40 | | | 7,497 |
| | 0-58 | | | | | 11,078 | | | | | 11,078 |
| | 0-59 | | | | 878 | 2,691 | | | | | 3,569 |
| | 0-60 | | | | 90 | 3,333 | | | | | 3,423 |
| | 0-62 | | | | | 3,720 | | | | | 3,720 |
| | 0-63 | | | | | 5,017 | | | | | 5,017 |
| | 0-66 | | | | | 6,825 | | | | | 6,825 |
| | 0-67 | | | | 3,458 | 4,257 | | | | | 7,715 |
| | 0-68 | | | | 1,824 | 5,135 | | | | | 6,959 |
| | 0-69 | | | | | 5,123 | | | | | 5,123 |
| | 0-70 | | | | | 3,125 | | | | | 3,125 |
| | 0-71 | | | | 1,637 | 3,272 | | | | | 4,909 |
| | 0-72 | | | | 4,273 | 6,266 | | | | | 10,539 |
| | 0-73 | | | | 975 | 289 | | | | | 1,264 |
| | 0-75 | | | | 360 | 3,160 | | | | | 3,520 |
| | 0-76 | | | | 3,006 | 4,097 | | | | | 7,103 |
| | Total | | | | 18,962 | 112,132 | | 182 | | | 131,276 |
| CLASS VIII | 0-49 | | | 5 | | | | 50 | | | 55 |
| | 0-50 | | | 60 | | | | | | | 60 |
| | 0-51 | | | | 5 | | | | | | 5 |
| | 0-53 | | | 2 | 40 | | | 19 | | | 61 |
| | 0-54 | | | 98 | | | | 27 | | | 125 |
| | 0-55 | | | 46 | 110 | | | 723 | | | 879 |
| | 0-56 | | | 13 | | | | 721 | | | 734 |
| | 0-57 | | | | | | | 35 | | | 35 |
| | 0-58 | | | 40 | 25 | | | 115 | | | 180 |
| | 0-59 | | | 1 | 25 | | | 162 | | | 188 |
| | 0-60 | | | 50 | 22 | | | 487 | | | 559 |
| | 0-62 | | | | 145 | | | 140 | | | 285 |
| | 0-63 | | | | 143 | | | 25 | | | 168 |
| | 0-66 | | | | | | | 69 | | | 69 |
| | 0-67 | | | | 22 | | | 132 | | | 154 |
| | 0-68 | | | | 26 | | | 284 | | | 310 |
| | 0-69 | | | | 85 | | | 445 | | | 530 |
| | 0-70 | | | | 861 | | | 1,124 | | | 1,985 |
| | 0-71 | | | 11 | 142 | 707 | | 187 | | | 1,047 |
| | 0-72 | | | 474 | 1,335 | 1,324 | | 1,094 | | | 4,227 |
| | 0-73 | | | 9 | 29 | | | | | | 38 |
| | 0-75 | | | | 68 | | | 26 | | | 94 |
| | 0-76 | | | | 75 | | | 117 | | | 192 |
| | Total | | | 809 | 3,158 | 2,031 | | 5,982 | | | 11,980 |
| GRAND TOTAL | | | | 98,704 | 362,867 | 257,324 | 2,447 | 66,441 | 91,304 | 36,428 | 915,515 |

1/ Unadjusted measurements, 1966, for Puget Sound Area Study, based on National Cooperative Soil Survey maps.

2/ Letters for subclasses denote hazards or conditions that affect land use and treatment: e - erosion; w - wetness; s - soil.

Table 9. Land conditions by capability classes and subclasses by watersheds (con.)
Elwha-Dungeness Basins

(in acres) 1/

| Class | Watershed Map Number | e | w | s | ew | es | we | ws | se | sw | Class Total |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Subclasses 2/ | | | | | | | | | |
| CLASS II | 0-77 | | | | | | | 7,247 | | | 7,247 |
| | 0-78 | | | | | | | 188 | | | 188 |
| | 0-79 | | | | | | | 198 | | | 198 |
| | 0-80 | | | | | | | 173 | | | 173 |
| | 0-81 | | | | | | | 61 | | | 61 |
| | 0-82 | | | | | | | 74 | | | 74 |
| | 0-83 | | | | | | | 483 | | | 483 |
| | Total | | | | | | | 8,424 | | | 8,424 |
| CLASS III | 0-77 | | | 2,278 | 6,472 | | | 2,589 | | | 11,339 |
| | 0-78 | | | 410 | 4,107 | | | 197 | | | 4,714 |
| | 0-79 | | | 210 | 4,016 | | | 433 | | | 4,659 |
| | 0-80 | | | | 6,744 | | | 525 | | | 7,269 |
| | 0-81 | | | | 934 | | | 68 | | | 1,002 |
| | 0-82 | | | 5 | 1,487 | | | 376 | | | 1,868 |
| | Total | | | 2,903 | 23,760 | | | 4,188 | | | 30,851 |
| CLASS IV | 0-77 | | | 1,699 | 1,561 | | | 2,586 | | | 5,846 |
| | 0-78 | | | 130 | 703 | | | 1,273 | | | 2,106 |
| | 0-79 | | | 16 | 27 | | | 1,080 | | | 1,123 |
| | 0-80 | | | 614 | 740 | | | 235 | | | 1,589 |
| | 0-81 | | | 135 | 326 | | | 37 | | | 498 |
| | 0-82 | | | 321 | 5,871 | | | 931 | | | 7,123 |
| | 0-83 | | | 931 | 839 | | | 885 | | | 2,655 |
| | | | | 3,846 | 10,067 | | | 7,027 | | | 20,940 |
| CLASS VI | 0-77 | | | 1,996 | 1,191 | | | | | | 3,187 |
| | 0-78 | | | 80 | 1,213 | | | | | | 1,293 |
| | 0-79 | | | 617 | 2,762 | | | | | | 3,379 |
| | 0-80 | | | 786 | 1,933 | | | | | | 2,719 |
| | 0-81 | | | 88 | 259 | | | | | | 347 |
| | 0-82 | | | 111 | 740 | | | | | | 851 |
| | 0-83 | | | 433 | 475 | | | | | | 908 |
| | Total | | | 4,111 | 8,573 | | | | | | 12,684 |
| CLASS VII | 0-77 | | | | 655 | 4,189 | | | | | 4,844 |
| | 0-78 | | | | | 2,464 | | | | | 2,464 |
| | 0-79 | | | | | 2,462 | | | | | 2,462 |
| | 0-80 | | | | | 5,698 | | | | | 5,698 |
| | 0-81 | | | | | 1,955 | | | | | 1,955 |
| | 0-82 | | | | | 5,830 | | | | | 5,830 |
| | 0-83 | | | | | 9,221 | | | | | 9,221 |
| | Total | | | | 655 | 31,819 | | | | | 32,474 |
| CLASS VIII | 0-77 | | | | 1,122 | | | 673 | | | 1,795 |
| | 0-78 | | | | | | | 62 | | | 62 |
| | 0-79 | | | | | | | 11 | | | 11 |
| | 0-80 | | | | 84 | | | 48 | | | 132 |
| | 0-81 | | | | 32 | | | | | | 32 |
| | 0-82 | | | | 441 | | | 53 | | | 494 |
| | 0-83 | | | | 86 | | | 332 | | | 418 |
| | Total | | | | 1,765 | | | 1,179 | | | 2,944 |
| GRAND TOTAL | | | | 10,860 | 44,820 | 31,819 | | 20,818 | | | 108,317 |

1/ Unadjusted measurements, 1966, for Puget Sound Area Study, based on National Cooperative Soil Survey maps.

2/ Letters for subclasses denote hazards or conditions that affect land use and treatment: e - erosion; w - wetness; s - soil.

Table 9. Land conditions by capability classes and subclasses by watersheds (con.)
San Juan Islands

(in acres) 1/

| Class | Watershed Map Number | Subclasses 2/ e | w | s | ew | es | we | ws | se | sw | Class Total |
|---|---|---|---|---|---|---|---|---|---|---|---|
| CLASS II | 0-11 | | | | | | | 278 | | | 278 |
| | 0-12 | | | | | | | 734 | | | 734 |
| | 0-13 | | | | | | | 272 | | | 272 |
| | Total | | | | | | | 1,284 | | | 1,284 |
| CLASS III | 0-11 | | | | 110 | | 2,411 | 1,937 | | 2,245 | 6,703 |
| | 0-12 | | | | 1,097 | | 1,053 | 5,185 | | 2,663 | 9,998 |
| | 0-13 | | | | 569 | | 1,131 | 3,697 | | 3,569 | 8,966 |
| | Total | | | | 1,776 | | 4,595 | 10,819 | | 8,477 | 25,667 |
| CLASS IV | 0-11 | | | | 2,628 | | | 999 | 551 | 99 | 4,277 |
| | 0-12 | | | | 3,744 | 20 | | 453 | 406 | 2,485 | 7,108 |
| | 0-13 | | | | 1,302 | | | 873 | 45 | 1,286 | 3,506 |
| | Total | | | | 7,674 | 20 | | 2,325 | 1,002 | 3,870 | 14,891 |
| CLASS VI | 0-11 | | | 2,386 | 2,034 | 18,684 | | 19 | 300 | | 23,423 |
| | 0-12 | | | 990 | 2,252 | 10,055 | | 40 | 830 | | 14,167 |
| | 0-13 | | | 1,373 | 1,920 | 4,385 | | 20 | 937 | | 8,635 |
| | Total | | | 4,749 | 6,206 | 33,124 | | 79 | 2,067 | | 46,225 |
| CLASS VII | 0-11 | | | | | 11,316 | | | | | 11,316 |
| | 0-12 | | | | | 6,717 | | | | | 6,717 |
| | 0-13 | | | | | 4,123 | | | | | 4,123 |
| | Total | | | | | 22,156 | | | | | 22,156 |
| CLASS VIII | 0-11 | | | | 340 | | | 6 | | | 346 |
| | 0-12 | | | | 259 | 90 | | 30 | | | 379 |
| | 0-13 | | | | 414 | 26 | | 185 | | | 625 |
| | Total | | | | 1,013 | 116 | | 221 | | | 1,350 |
| GRAND TOTAL | | | | 4,749 | 16,669 | 55,416 | 4,595 | 14,728 | 3,069 | 12,347 | 111,573 |

1/ Unadjusted measurements, 1966, for Puget Sound Area Study, based on National Cooperative Soil Survey maps.
2/ Letters for subclasses denote hazards or conditions that affect land use and treatment: e - erosion; w - wetness; s - soil.

Table 10. Land capability units in Puget Sound Area
(acres) 1/

Sheet 1 of 3

| Capability units | BASINS | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Nooksack-Sumas | Skagit-Samish | Stilla-guamish | Whidbey-Camano | Snoho-mish | Cedar | Green | Puyallup | Nisqually | Deschutes | West Sound | Elwha-Dungeness | San Juan | Total |
| II ws 02 | 5,704 | 16,519 | | | 1,679 | 351 | 3,186 | 60 | | | | | | 27,499 |
| II ws 03 | 15,830 | 27,062 | 689 | | 13,887 | 4,038 | 14,179 | 19,864 | 1,411 | 1,180 | 3,778 | 6,297 | | 108,215 |
| II ws 04 | 7,165 | 36,500 | 16,247 | 1,643 | 23,230 | 3,346 | 4,020 | 1,204 | 715 | 2,386 | 4,131 | 1,317 | | 101,904 |
| II ws 06 | 12,097 | 2,069 | 3,391 | 2,090 | 12,545 | 6,080 | 3,294 | 3,025 | 3,265 | 3,797 | 10,576 | 810 | 1,284 | 64,323 |
| II ws 09 | | | | | | | 529 | 2,770 | 424 | | | | | 3,723 |
| II ws 12 | | | | 1,063 | | | | | | | | | | 1,063 |
| II so 01 | 2,035 | 862 | | | 286 | | | | 596 | | | | | 3,779 |
| II sw 02 | | | | | | | | | | | 1,498 | | | 1,498 |
| II sw 03 | | | | 651 | | | | | | | 167 | | | 818 |
| Class II total | 42,831 | 83,012 | 20,327 | 5,447 | 51,627 | 13,815 | 25,208 | 26,923 | 6,411 | 7,363 | 20,150 | 8,424 | 1,284 | 312,822 |
| III ew 01 | 11,486 | 1,600 | 4,691 | 156 | 12,552 | 7,159 | 591 | 2,177 | 833 | | 54,172 | | 1,776 | 97,193 |
| III ew 03 | | | | | | | | | | | 16,927 | 23,760 | | 40,687 |
| III es 02 | 255 | 2,416 | 2,640 | | 1,427 | | | | 40 | 55 | 3,471 | | | 10,304 |
| III we 16 | 11,762 | | | | | | | | | | | | 4,595 | 16,357 |
| III we 17 | | | | | | | 1,961 | 17,415 | 35,143 | | 2,437 | | | 56,956 |
| III ws 01 | 11,044 | 22,157 | 5,236 | | 9,296 | 33 | | 963 | 2,164 | 1,336 | 1,667 | | | 53,896 |
| III ws 02 | 1,734 | 2,229 | 60 | | | | | | 20 | 193 | 436 | | | 4,672 |
| III ws 03 | 476 | 1,210 | | 187 | | | | 72 | 20 | | 748 | | | 2,713 |
| III ws 04 | | | | | | | | | | | 1,046 | 1,438 | 395 | 2,879 |
| III ws 05 | | 361 | | | 484 | 1,073 | 586 | 71 | 532 | 1,070 | 9,093 | | | 13,270 |
| III ws 08 | 23,566 | 150 | 1,024 | | 6,439 | 422 | | 185 | 148 | 457 | 3,335 | | | 35,726 |
| III ws 09 | 8,788 | 1,407 | 2,384 | 2,608 | 8,633 | 5,044 | 1,440 | 969 | 2,232 | 564 | 3,653 | | 675 | 38,397 |
| III ws 10 | 25,905 | 4,756 | 825 | 3,278 | 2,103 | 80 | 4,089 | 13,410 | 4,008 | 2,808 | 4,822 | 2,750 | 7,213 | 76,047 |
| III ws 11 | 556 | | | | | | | | | | 456 | | 2,536 | 3,548 |
| III ws 12 | 8,833 | 347 | | | 35 | | 9 | 4,572 | 5,155 | 4,489 | 1,001 | | | 24,441 |
| III so 01 | 6,028 | 6,980 | 5,759 | | 4,207 | 15 | | | | | | | | 22,989 |
| III so 06 | | | | | | | | | | | | 2,903 | | 2,903 |
| III so 08 | 6,419 | 1,602 | | | 247 | 15 | | | 1,059 | 7,128 | 830 | | | 17,300 |
| III sw 04 | | | | | | | | | | | | | 250 | 250 |
| III sw 09 | | 444 | 200 | | 1,093 | 255 | | | | 60 | 1,132 | | 8,227 | 11,411 |
| Class III total | 116,852 | 45,659 | 22,819 | 6,229 | 46,516 | 14,096 | 8,676 | 39,834 | 51,354 | 18,160 | 105,226 | 30,851 | 25,667 | 531,939 |
| IV ew 03 | | | | 38,114 | | | | 8,235 | 7,720 | | 22,782 | 10,067 | | 86,918 |
| IV ew 12 | 30,007 | 14,469 | | 2,144 | 130 | | | 521 | 134 | | 1,360 | | 2,140 | 50,905 |
| IV ew 14 | 14,422 | 7,689 | 195 | | | | | 15,655 | 16,846 | 6,578 | 16,788 | | | 78,173 |
| IV ew 22 | 2,715 | 18,025 | 21,642 | 9,519 | 125,285 | 117,705 | 66,421 | 40,075 | 5,597 | 7,349 | 157,220 | | 5,534 | 577,087 |
| IV es 06 | 15,099 | 1,841 | | | | | | | | | | | | 16,940 |
| IV es 07 | | | | | | | | | 1,133 | | | | | 1,133 |
| IV es 08 | | 3,978 | | | 4,626 | | | | | | | | | 8,604 |
| IV es 09 | 1,896 | 2,262 | 300 | | 320 | 1,903 | 5,219 | 35 | 710 | 5,362 | 25,561 | | | 43,568 |
| IV es 10 | | | | 725 | | | | | | | 63 | | | 788 |
| IV es 11 | | | | | | | | | | | | | 20 | 20 |
| IV es 13 | 1,998 | | | | | | | | | | | | | 1,998 |
| IV es 16 | | | | | | | | | 5 | 390 | 323 | | | 718 |
| IV ws 01 | 221 | 5 | | | | | | 282 | 270 | | | 1,685 | | 2,463 |
| IV ws 02 | 1,096 | 178 | | | | | | 3,063 | 80 | 328 | 21 | | | 4,766 |

Table 10. Land capability units in Puget Sound Area
(acres) 1/



| Capability units | BASINS Noosack-Sumas | Skagit-Samish | Stilla-guamish | Whidbey-Camano | Snoho-mish | Cedar | Green | Puyallup | Nisqually | Deschutes | West Sound | Elwha-Dungeness | San Juan | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Class IV (con) | | | | | | | | | | | | | | |
| IV ws 03 | | 23 | | | | | | | | | | | | 23 |
| IV ws 05 | | 235 | 519 | | 640 | 94 | 65 | 110 | 18 | 15 | 78 | | | 1,774 |
| IV ws 06 | 4,785 | 2,167 | 1,900 | 1,253 | 2,729 | 1,546 | 604 | 4,537 | 2,892 | 1,083 | 5,311 | 30 | 389 | 29,226 |
| IV ws 07 | | | | | | | | | 348 | | | | | 348 |
| IV ws 08 | | | | | | | | | | | 2,602 | | | 2,602 |
| IV ws 09 | | | | | | | | 853 | 4,249 | 996 | 1,028 | | | 7,126 |
| IV ws 10 | 362 | 1,606 | 140 | | 225 | 1,698 | 490 | 493 | 95 | 369 | 1,327 | 84 | | 6,889 |
| IV ws 11 | 1,090 | 16,076 | 35 | 4,618 | | | | 58 | 786 | | | | 1,936 | 24,599 |
| IV ws 12 | | | | | | | | | | | 1,053 | | | 1,053 |
| IV ws 13 | | | | | | | | | | | 1,224 | 5,228 | | 6,452 |
| IV ws 43 | | 94 | | 1,449 | | | | | | | 831 | | | 2,374 |
| IV so 01 | 19,876 | 1,981 | 5,556 | | 16,670 | 16,907 | 17,996 | 3,184 | 5 | | 3,230 | 2,218 | | 87,623 |
| IV so 10 | | | | 1,531 | 19 | | | 46,335 | 36,955 | 24,560 | 152 | 1,628 | | 111,180 |
| IV so 12 | | | | | | | | 1 | 3,170 | | | | | 3,171 |
| IV se 05 | 4,970 | 265 | 125 | 2,310 | 746 | 6,233 | 2,391 | 4,755 | 1,916 | 2,008 | 7,540 | | 1,002 | 34,261 |
| IV se 10 | | | | | | | | | | | 389 | | | 389 |
| IV se 11 | | | | 30 | | | | | 14 | 2,030 | | | | 2,074 |
| IV se 13 | | | | | 1,466 | | | 199 | | | 3 | | | 1,668 |
| IV se 06 | 9 | | | | | | | | | | 19,785 | | | 19,794 |
| IV sw 09 | | 2,241 | | 335 | 823 | 300 | | | 847 | 3,457 | 13,846 | | 3,870 | 25,719 |
| Class IV total | 98,546 | 73,135 | 30,412 | 62,028 | 153,679 | 146,386 | 93,186 | 128,391 | 83,790 | 54,525 | 282,517 | 20,940 | 14,891 | 1,242,426 |
| II-IV total | 258,229 | 201,806 | 73,558 | 73,704 | 251,822 | 174,297 | 127,070 | 195,148 | 141,555 | 80,048 | 407,893 | 60,215 | 41,842 | 2,087,187 |
| V ws 21 | 240 | 39 | | | 911 | 664 | 230 | 219 | | | 138 | | | 2,441 |
| Class V total | 240 | 39 | | | 911 | 664 | 230 | 219 | | | 138 | | | 2,441 |
| VI ew 21 | 10,154 | 10,735 | 15,541 | 2,572 | 24,603 | 18,112 | 4,774 | 11,940 | 8,886 | 3,585 | 57,979 | | 3,735 | 172,616 |
| VI ew 23 | | | | | | | | | | | 2,712 | 8,573 | | 11,285 |
| VI ew 26 | | 2,499 | | 9,426 | | | | 428 | 395 | | 10,756 | | | 23,504 |
| VI ew 28 | 3,651 | 1,167 | | 147 | 1,963 | | | 1,078 | 2 | | 51 | | 2,720 | 10,779 |
| VI es 17 | | | | 25 | | | | | | | | | 248 | 273 |
| VI es 18 | 251 | | | | | | | | 50 | 752 | | | | 1,053 |
| VI es 19 | 6,748 | 8,353 | 5,353 | 2,658 | 20,406 | 9,817 | 2,329 | 21,865 | 5,919 | 7,111 | 45,307 | | | 135,866 |
| VI es 20 | 2,301 | 3,260 | 680 | | | 749 | 1,282 | 160 | 65 | 1,707 | 15,370 | | | 25,574 |
| VI es 21 | | | | | | | | 20 | 2,556 | 1,654 | | | | 4,230 |
| VI es 22 | 9 | 2,762 | 270 | 9,033 | 1,183 | 364 | | | | | 1,676 | | | 15,297 |
| VI es 23 | | | | | | | | | | | 418 | | | 418 |
| VI es 24 | | | | | | | | | | | 39,220 | | | 39,220 |
| VI es 25 | 11 | 60 | | | | | | | 38 | 3,120 | 2,779 | | 10,368 | 16,376 |
| VI es 27 | | 2,441 | | | | | | | | | 8,973 | | 22,259 | 33,673 |
| VI ws 02 | | | | 427 | | | | | | | | | 79 | 506 |
| VI ws 19 | 4,144 | 7,083 | 315 | | 4,096 | 1,263 | 1,157 | 5,247 | 3,043 | | 1,932 | | | 28,280 |
| VI so 01 | | | | | 4,075 | 1,539 | 167 | 3,419 | 3,108 | 2,272 | 20 | | | 14,600 |
| VI so 10 | 991 | | | | | | | | | | 30 | 1,040 | 35 | 2,096 |

Table 10. Land capability units in Puget Sound Area
(acres) 1/

Sheet 3 of 3

| Capability units | Nooksack-Sumas | Skagit-Samish | Stilla-guamish | Whidbey-Camano | Snoho-mish | Cedar | Green | Puyallup | Nisqually | Deschutes | West Sound | Elwha-Dungeness | San Juan | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | BASINS | | | | | | | | | | | | | |
| Class VI (con) | | | | | | | | | | | | | | |
| VI so 12 | | 6,761 | 850 | 5,587 | 1,125 | | | 3,713 | 3,755 | | 4,251 | | | 26,042 |
| VI so 13 | | 232 | 130 | 12,308 | | | | | | | | | | 12,670 |
| VI so 14 | | | | | | | | | | | 19,840 | | | 19,840 |
| VI so 16 | | | | | | | | | | | 467 | | | 467 |
| VI so 18 | 346 | 18,658 | 23,700 | 300 | 27,845 | 6,736 | 5,420 | 16,675 | 11,766 | 8,844 | 65,055 | 3,071 | 3,953 | 192,369 |
| VI so 19 | | | | | | | | 323 | 297 | 1,938 | 62 | | | 2,620 |
| VI so 21 | | | | 984 | | | | 272 | 2,276 | 767 | 3,958 | | 761 | 9,018 |
| VI se 13 | 235 | 1,239 | 185 | 6,821 | 14,425 | 50 | 942 | 528 | | | 4,459 | | | 28,884 |
| VI se 15 | | | | | | | | | | 40 | 10,511 | | | 10,551 |
| VI se 17 | 131 | 2,871 | 4,206 | 1,151 | 26,507 | 14,959 | 5,514 | 22,741 | 24,284 | 12,178 | 68,379 | | 1,274 | 184,195 |
| VI se 21 | | | | | 85 | | | 595 | 140 | 451 | 23 | | 793 | 2,087 |
| Class VI total | 28,972 | 68,121 | 51,230 | 51,439 | 126,313 | 53,589 | 21,585 | 89,004 | 66,580 | 44,419 | 364,228 | 12,684 | 46,225 | 1,024,389 |
| VII ew 30 | 83 | 1,943 | 1,175 | | | | | | | 995 | 15,405 | | | 19,601 |
| VII ew 31 | 643 | 780 | | | | | | | | | | | | 1,423 |
| VII ew 32 | | | | | | | | | | | 3,557 | 655 | | 4,212 |
| VII es 29 | 212 | 3,206 | 230 | 285 | 1,652 | | | 2,416 | 13,829 | 6,290 | 4,014 | | 244 | 32,378 |
| VII es 30 | | | | | | | | | | | 1,934 | | | 1,934 |
| VII es 33 | | | | | | | | | | 185 | | | | 185 |
| VII es 34 | | 684 | | | | | | | | | 415 | | | 1,099 |
| VII es 35 | 394 | 6,673 | 595 | | | 56 | 71 | | | | 17,193 | | 11,027 | 36,009 |
| VII es 36 | 224,618 | 229,874 | 125,472 | 3,131 | 272,069 | 40,358 | 58,529 | 159,247 | 138,324 | 33,688 | 88,576 | 31,819 | 10,885 | 1,416,590 |
| VII ws 20 | 2 | 435 | | | 502 | | | 1,313 | 372 | | 182 | | | 2,806 |
| VII so 23 | | 1,105 | 3,406 | | 2,430 | | | | 1,649 | 938 | | | | 9,528 |
| Class VII total | 225,952 | 244,700 | 130,878 | 3,416 | 276,653 | 40,414 | 58,600 | 162,976 | 154,174 | 42,096 | 131,276 | 32,474 | 22,156 | 1,525,765 |
| VIII ew 39 | 443 | 504 | | 2,042 | 289 | 134 | 87 | 114 | | | 3,157 | 1,765 | 1,013 | 9,548 |
| VIII es 37 | | | | | | | | | | | 1,875 | | | 1,875 |
| VIII es 38 | | | | | | | | | | | 156 | | 116 | 272 |
| VIII ws 00 | 1,839 | 3,373 | 1,548 | | 2,311 | 347 | 395 | 4,062 | 999 | 122 | 682 | 779 | | 16,457 |
| VIII ws 22 | 139 | | | 1,017 | | | | | | | | | | 1,156 |
| VIII ws 23 | 400 | 3,770 | 760 | 543 | 858 | 84 | 66 | 398 | 197 | 460 | 2,674 | 110 | 166 | 10,486 |
| VIII ws 24 | 24 | 151 | 341 | 99 | 1,308 | 494 | 378 | 277 | 40 | 83 | 2,627 | 290 | 55 | 6,167 |
| VIII so 00 | 248 | 717 | 10 | 675 | 305 | 178 | 288 | 2,011 | | 350 | 809 | | | 5,591 |
| Class VIII total | 3,093 | 8,515 | 2,659 | 4,376 | 5,071 | 1,237 | 1,214 | 6,862 | 1,236 | 1,015 | 11,980 | 2,944 | 1,350 | 51,552 |
| V-VIII total | 258,257 | 321,375 | 184,767 | 59,231 | 408,948 | 95,904 | 81,629 | 259,061 | 221,990 | 87,530 | 507,622 | 48,102 | 69,731 | 2,604,147 |
| II-VIII total | 516,486 | 523,181 | 258,325 | 132,935 | 660,770 | 270,201 | 208,699 | 454,209 | 363,545 | 167,578 | 915,515 | 108,317 | 111,573 | 4,691,334 |

1/ Unadjusted measurements, 1966, for Puget Sound Area Study, based on National Cooperative Soil Survey maps. Does not include lands within national forest or park boundaries.

Table 11. Crop yields by land capability units in Puget Sound Area

| Typical soil type for capability unit | Land capability unit | Hay, grass & legumes (Tons) A | Hay, grass & legumes (Tons) B | Hay, alfalfa (Tons) A | Hay, alfalfa (Tons) B | Pasture (AUM) A | Pasture (AUM) B | Silage (Tons) A | Silage (Tons) B | Small grain (Tons) A | Small grain (Tons) B | Potatoes (Tons) A | Potatoes (Tons) B | Peas (Tons) A | Peas (Tons) B | Pole beans (Tons) A | Pole beans (Tons) B | Sweet corn (Tons) A | Sweet corn (Tons) B | Broccoli (Tons) A | Broccoli (Tons) B | Strawberries (Tons) A | Strawberries (Tons) B | Cane berries (Tons) A | Cane berries (Tons) B |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Giles silt loam | IIs1 | 2.0 | 6.0 | | | 4.75 | 14.25 | 6.2 | 18.6 | 0.75 | 1.0 | | | | | | | 5.0 | 7.0 | | | 3.0 | 7.0 | | |
| Agnew loam | IIsw2 | 5.0 | 8.0 | | | 11.75 | 19.0 | 15.0 | 24.8 | 1.25 | 2.5 | | 12.5 | | 1.25 | | | | | | | | | | |
| Ebeys sandy loam | IIsw3 | 4.0 | 6.5 | 5.0 | 8.0 | 9.5 | 15.5 | 12.4 | 20.1 | 1.3 | 2.5 | | | | 1.25 | | | | | | | | | | |
| Puyallup silty clay loam | IIws2 | 2.5 | 6.0 | | 6.0 | 6.0 | 14.25 | 7.7 | 18.6 | | | | | | | 4.0 | 6.0 | 3.0 | 4.0 | | | 2.0 | 5.0 | 3.0 | 4.0 |
| Nooksack silt loam | IIws3 | 3.0 | 8.5 | | | 7.0 | 20.0 | 9.3 | 26.3 | 0.5 | 1.0 | 12.0 | 18.0 | | | | | 5.0 | 8.0 | | | | | | |
| Puget silty clay loam | IIws4 | 3.0 | 8.0 | | | 7.0 | 19.0 | 9.3 | 24.8 | 1.8 | 2.4 | | | | 2.6 | | | 6.0 | 8.0 | 4.0 | 6.0 | | 5.0 | | |
| Semiahmoo muck | IIws6 | 3.5 | 8.0 | | | 8.25 | 19.0 | 10.8 | 24.8 | | | 12.0 | 20.0 | 2.0 | 3.0 | 3.0 | 5.0 | 4.5 | 6.5 | | | | | | |
| Orting loam | IIws9 | 3.5 | 5.0 | | | 8.25 | 12.0 | 10.8 | 15.5 | 1.0 | 1.5 | | | | 1.5 | | | | | | | | | 2.5 | 4.5 |
| Coupeville silt loam | IIws12 | 3.5 | 5.0 | | 4.0 | 8.25 | 12.0 | 10.8 | 15.5 | 1.3 | | | | | | | | | | | | | | | |
| Cathcart loam | IIIes2 | 3.5 | 6.0 | | | 8.25 | 14.25 | 10.8 | 18.6 | 0.5 | | | | | | | | | | | | 3.0 | 4.5 | | |
| Kitsap silt loam 3-8% | IIIew1 | 2.5 | 7.0 | | | 6.0 | 16.5 | 7.75 | 21.7 | | | | | | | | | | | | | 2.5 | 4.5 | | |
| Clallam loam | IIIew3 | 2.0 | 5.0 | | | 4.75 | 12.0 | 6.2 | 15.5 | 0.5 | 1.5 | | | | | | | | | | | | | | |
| Lynden loam | IIIs1 | 2.0 | 6.0 | | 5.0 | 4.75 | 14.25 | 6.2 | 18.6 | | | 12.0 | 14.0 | | | | | | | | | 4.0 | 6.0 | 4.0 | 6.0 |
| Dick loamy fine sand | IIIs6 | 1.0 | 6.5 | | | 2.25 | 15.5 | 3.1 | 20.1 | 0.5 | 1.0 | | | | | | | | | | | | 4.5 | | |
| Giles loam | IIIs8 | 2.0 | 8.0 | | | 4.75 | 19.0 | 6.2 | 24.8 | 0.75 | 1.0 | | | | | | | 5.0 | 7.0 | | | 3.0 | 7.0 | | |
| Roche gravelly loam | IIIsw09 | 1.0 | 2.5 | 1.0 | 2.5 | 2.25 | 6.0 | 3.1 | 7.75 | 0.5 | 1.3 | | | | | | | | | | | | | | |
| Whatcom silt loam 3-8% | IIIwe16 | 3.0 | 7.0 | | | 7.0 | 16.5 | 9.3 | 21.7 | 0.5 | 1.0 | | | | | | | | | | | | | | |
| 8-15% | & IVew12 | | | | | | | | | | | | | | | | | | | | | | | | |
| Kapowsin gravelly loam | IIIwe17 | 2.5 | 3.5 | | | 6.0 | 8.25 | 7.75 | 10.8 | 0.7 | 1.0 | | | | | | | | | | | 2.0 | 3.5 | 2.5 | 4.5 |
| Puyallup fine sandy loam | IIIws1 | 2.5 | 7.0 | | 6.0 | 7.75 | 16.5 | 10.0 | 21.7 | | | | | | | 4.0 | 6.0 | 3.0 | 4.0 | | | 4.0 | 7.0 | 3.5 | 4.5 |
| Kline silt loam | IIIws2 | 3.25 | 7.0 | | | 7.75 | 16.5 | 10.0 | 21.8 | | | | | | | | | | | | | | | | |
| Lummi silty clay loam | IIIws3 | 2.5 | 7.5 | | | 6.0 | 17.75 | 7.75 | 23.2 | 0.75 | 1.0 | | | 1.5 | 3.0 | | | 6.0 | 8.0 | | | | | | |
| Sequim gravelly loam | IIIws4 | 1.0 | 5.5 | | | 2.25 | 13.0 | 3.1 | 15.5 | 0.5 | 1.5 | | | | | | | | | | | | | | |
| Sammamish silt loam | IIIws5 | 2.5 | 4.0 | | | 6.0 | 9.5 | 7.75 | 12.4 | | | | | | | | | | | 3.0 | 4.0 | | | | |
| Edmonds sandy loam | IIIws8 | 2.0 | 3.5 | | | 4.75 | 8.25 | 6.2 | 10.8 | | | | | | | | | | | | | | | | |
| Norma loam | IIIws9 | 2.0 | 5.5 | | | 4.75 | 13.0 | 6.2 | 10.8 | | | | | | | | | | | | | | | | |
| Bellingham silty clay loam | IIIws10 | 2.5 | 5.0 | | | 6.0 | 11.75 | 7.75 | 15.5 | 1.75 | 2.4 | | | | | | | | | | | | | | |
| Hemmi silt loam | IIIws11 | 1.5 | 6.0 | | | 3.5 | 14.25 | 4.65 | 18.6 | 0.5 | 1.0 | 12.0 | 17.0 | | | 4.0 | 8.0 | | | | | | | | |
| Kitsap silt loam 0-3% | IIIws12 | 2.5 | 7.0 | | | 6.0 | 16.5 | 7.75 | 21.7 | | | | | | | | | | | | | 2.5 | 4.5 | | |

Table 11. Crop yields by land capability units in Puget Sound Area (con.)

| Typical soil type for capability unit | Land capability unit | Hay, grass & legumes (Tons) A | Hay, grass & legumes (Tons) B | Hay, alfalfa (Tons) A | Hay, alfalfa (Tons) B | Pasture (AUM) A | Pasture (AUM) B | Silage (Tons) A | Silage (Tons) B | Small grain (Tons) A | Small grain (Tons) B | Potatoes (Tons) A | Potatoes (Tons) B | Peas (Tons) A | Peas (Tons) B | Pole beans (Tons) A | Pole beans (Tons) B | Sweet corn (Tons) A | Sweet corn (Tons) B | Broccoli (Tons) A | Broccoli (Tons) B | Strawberries (Tons) A | Strawberries (Tons) B | Cane berries (Tons) A | Cane berries (Tons) B |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Kickerville silt loam 8-15% | IVes6 | 1.0 | 5.0 | | | 2.25 | 11.75 | 5.1 | 15.5 | 0.5 | 1.0 | 7.0 | 12.0 | | | | | | | | | | | | |
| Sol Duc gravelly loam 8-15% | IVes7 | | 4.5 | | | | 10.5 | | 13.9 | | 1.75 | | | | | | | | | | | 3.0 | 3.8 | | |
| Skiyou gravelly loam | IVes8 | 1.75 | 2.25 | | | 4.25 | 5.25 | 5.4 | 7.0 | | | | | | | | | | | | | | | | |
| Shelton gravelly sandy loam 8-15% | IVes9 | 2.0 | 8.0 | 2.7 | | 4.75 | 19.0 | 6.2 | 24.8 | 0.6 | | | | | | | | | | | | 1.5 | 2.0 | | |
| Townsend sandy loam | IVes10 | 4.5 | 7.5 | | 3.0 | 10.75 | 17.75 | 13.9 | 23.2 | | 1.0 | | | | | | | | | | | | | | |
| San Juan gravelly sandy loam 8-15% | IVes11 | 0.5 | 1.5 | 1.4 | 1.7 | 1.25 | 3.5 | | 4.6 | 0.3 | 0.7 | | | | | | | | | | | | | | |
| Heisler shaly loam | IVes13 | 2.0 | 4.0 | | | 4.75 | 9.5 | 6.2 | 12.4 | | | | | | | | | | | | | | | | |
| Melbourne silty clay loam | IVes16 | 2.0 | 2.5 | | | 4.75 | 6.0 | 6.2 | 7.0 | 0.4 | 0.6 | | | | | | | | | | | | | | |
| Sinclair shotty loam | IVew3 | 1.75 | 2.5 | 2.5 | 2.8 | 4.25 | 6.0 | 5.4 | 7.75 | 0.8 | 0.4 | | | | | | | | | | | 1.3 | 2.2 | | |
| Whatcom silt loam 8-15% | IVew126 | | | | | | | | | | | | | | | | | | | | | | | | |
| 3-8% | IIIwe16 | 3.0 | 7.0 | | | 7.0 | 16.5 | 9.3 | 21.7 | 0.5 | 1.0 | | | | | | | | | | | | | | |
| Kitsap silty clay loam 8-15% | IVew14 | 2.0 | 5.0 | | | 4.75 | 11.75 | 6.2 | 15.5 | | | | | | | | | | | | | | | | |
| Alderwood gravelly sandy loam | IVew22 | 1.75 | 5.0 | | | 4.25 | 12.0 | 5.4 | 15.5 | | | | | | | | | | | | | 2.0 | 4.0 | 3.0 | 6.0 |
| Lynden sandy loam 3-8% | IVs1 | 1.5 | 6.0 | | | 3.5 | 14.22 | 4.6 | 18.6 | 0.5 | 2.0 | | 15.0 | | | | | | | | | 3.0 | 7.0 | | |
| Lynden sandy loam 8-15% | IVs5 | 1.5 | 6.0 | | | 3.5 | 14.25 | 4.6 | 18.6 | 0.5 | 2.0 | | 15.0 | | | | | | | | | | 7.0 | | |
| Spanaway gravelly sandy loam | IVs10 | 1.5 | 2.5 | | | 3.5 | 6.0 | 4.6 | 7.75 | 0.3 | 2.0 | | | | | | | | | | | | | | |
| National pumicy sandy loam | IVs12 | 1.75 | 3.0 | | | 4.25 | 7.0 | 5.4 | 9.3 | 0.7 | 1.0 | | | | | | | | | | | | | | |
| Indianola fine sandy loam 8-15% | IVse05 | 1.5 | 6.0 | | | 3.5 | 14.25 | 4.6 | 18.6 | 0.5 | 2.0 | | 15.0 | | | | | | | | | 3.0 | 7.0 | | |
| Ragnar fine sandy loam 8-15% | IVse13 | 1.5 | 6.0 | | | 3.5 | 14.25 | 4.6 | 18.6 | 0.5 | 2.0 | | 15.0 | | | | | | | | | | 7.0 | | |
| Whidbey gravelly sandy loam 3-8% | IVsw6 | 3.0 | 7.5 | | | 7.0 | 14.25 | 9.3 | 18.6 | | | | | | | | | | | | | | | | |
| Alderwood gravelly sandy loam 3-8% | IVsw9 | 1.75 | 3.5 | | | 4.25 | 8.25 | 5.4 | 10.8 | | | | | | | | | | | | | 2.0 | 4.0 | 3.0 | 6.0 |
| Pilchuck fine sandy loam | IVws1 | 0.75 | 1.0 | | | 1.75 | 2.25 | | 3.1 | | | | | | | | | | | | | | | | |
| Puget clay | IVws5 | 1.0 | 2.0 | | | 2.35 | 4.75 | 3.1 | 6.2 | | | | | | | | | | | | | | | 4.0 | 5.0 |
| Semiahmoo muck, shallow | IVws6 | 3.25 | 4.0 | | | 7.75 | 9.5 | 10.0 | 12.4 | 1.1 | 1.9 | | | | | | | | | | | | | | |
| Schooley loam | IVws7 | 2.5 | 3.0 | 3.5 | | 6.0 | 7.0 | 7.75 | 9.3 | | | | | | | | | | | | | | | | |
| Koch silt loam | IVws8 | 3.0 | 5.0 | | | 7.0 | 12.0 | 9.3 | 15.5 | 0.6 | | | | 1.0 | | | | | | | | | | 1.8 | |
| McKenna gravelly loam | IVws9 | 3.5 | 4.5 | | | 8.25 | 10.75 | 10.8 | 13.9 | | | | | | | | | | | | | | | | |
| Bellingham silty clay | IVws10 | 2.5 | 5.0 | | | 6.0 | 12.0 | 7.75 | 15.5 | | | | | | | | | | | | | | | | |
| Bow gravelly loam | IVws11 | 1.5 | 4.0 | | | 3.5 | 9.5 | 4.6 | 12.4 | 0.06 | 1.75 | | | | | | | | | | | | | | |
| Agnew silty clay loam | IVws13 | 5.0 | 8.0 | | | 11.75 | 19.0 | 15.5 | 24.8 | 1.0 | 2.0 | | | 1.0 | 3.0 | | | | 6.0 | | | | | | |
| Bozarth fine sandy loam | IVws43 | 2.5 | 4.0 | | | 6.0 | 9.5 | 7.75 | 12.4 | 0.06 | | | | | | | | | | | | | | | |

## Land Capability Unit Descriptions 1/

Land Capability Unit IIws02 (IIw1) consists of deep, medium, and moderately fine textured, slowly and moderately slowly permeable soils on bottom lands and river flood plains.

Management problems are wetness and maintenance of soil productivity. Flood prevention and improved land drainage make these soils well suited for growing hay and pasture, row crops, vegetables, forage, and small grains. The soils are suited for continuous cropping with the use of winter cover crops and green manures. Also, they are suited for growing hay and pasture 3 to 4 years, followed by strawberries 3 to 4 years; or hay and pasture 5 to 10 years, with row crops 1 to 2 years. Such areas, protected to reduce flood damage to a minimum, and provided with adequate drainage, will produce high crop yields under a high level of management. Moderate water intake rates and water-holding capacities make these soils well suited for supplemental irrigation. Some crop yields are materially increased by irrigation during periods of low precipitation that might otherwise interrupt growth.

| Mapping Unit | % Slope | ADP Code | Mapping Unit | % Slope | ADP Code | Mapping Unit | % Slope | ADP Code |
|---|---|---|---|---|---|---|---|---|
| Puyallup sicl* | 0-3 | 22302 | Sultan fsl | 0-3 | 22302 | Sumas sil, shallow | 0-3 | 22302 |
| Sultan sil | 0-3 | " | Sumas sil | 0-3 | " | Sumas sicl | 0-3 | " |
| Sultan sil | 3-8 | " | Sumas sil, deep | 0-3 | " | Sumas fsl | 0-3 | " |
| Sultan cl | 0-3 | " | | | | | | |

Land Capability Unit IIws03 (IIw2) consists of deep, well and moderately well drained, moderately coarse, and medium textured soils on gently sloping river flood plains.

Management problems are wetness by overbank flow flooding and maintenance of soil productivity. The soils are well suited for growing row crops, vegetables, vegetable seeds, strawberries, small grains, hay, and pasture. High yields can be maintained under an intensive conservation management program. Productivity of the soils and soil structure can be maintained under continuous cropping with the use of complete commercial fertilizers, winter cover crops, and green manures. Also, they can be maintained by growing hay and pasture 3 to 4 years, followed by strawberries 3 to 4 years; or hay and pasture 5 to 10 years, followed by row crops 1 to 2 years, with winter cover crops between consecutive years of row crops. Any combination of the conservation measures outlined above is designed to protect the soil against deterioration and to provide average to high yields. Crops respond well to supplemental irrigation during periods of low precipitation that might otherwise interrupt their growth cycle. The water intake rates are moderate and water-holding capacities are high.

| Mapping Unit | % Slope | ADP Code | Mapping Unit | % Slope | ADP Code | Mapping Unit | % Slope | ADP Code |
|---|---|---|---|---|---|---|---|---|
| Belfast sil | 0-3 | 22303 | Newberg sil | 0-3 | 22303 | Puyallup sil | 3-8 | 22303 |
| Camas cl | 0-3 | " | Nooksack sil* | 0-3 | " | Puyallup vfsl | 0-3 | " |
| Dungeness l | 0-3 | " | Nooksack fsl | 0-3 | " | Puyallup fsl | 0-3 | " |
| Dungeness sil | 0-3 | " | Puyallup l | 0-3 | " | Sultan l | 0-3 | " |
| Dungeness fsl | 0-3 | " | Puyallup sil | 0-3 | " | Sultan sil | 0-3 | " |
| Edgewick sil | 0-3 | " | | | | | | |

Land Capability Unit IIws04 (IIw3) consists of deep, medium and moderately fine textured soils, with slowly and moderately slowly permeable, fine textured subsoils. The soils occur on gently sloping alluvial flood plains and low terraces.

Management problems are wetness and maintenance of soil productivity. Flood prevention and improved land drainage are essential for growing row crops, vegetables, forage, small grains, hay, and pasture. These soils are suited for continuous cropping with the use of complete commercial fertilizers, winter cover crops, and green manures; also, they are suited for growing hay and pasture 3 to 4 years, with strawberries 3 to 4 years; or hay and pasture 5 to 10 years, followed by row crops 1 to 2 years, with winter cover crops between successive years of row crops. High crop yields are produced under a high level of conservation management on areas provided with drainage required by specific crops, with protection against flooding and sediment damages. Crops respond well to careful supplemental irrigation during periods of low precipitation. Overirrigation may aggravate the drainage problem and cause reduction of crop yields, particularly for those crops which require good drainage to depths of 20 inches or more.

| Mapping Unit | % Slope | ADP Code | Mapping Unit | % Slope | ADP Code | Mapping Unit | % Slope | ADP Code |
|---|---|---|---|---|---|---|---|---|
| Chehalis l | 0-3 | 22304 | Maytown l | 0-3 | 22304 | Samish sil | 0-3 | 22304 |
| Chehalis sil, mottled | 0-3 | " | Nookachamps sicl | 0-3 | " | Shuwah sicl | 0-3 | " |
| Chehalis sicl, " | 0-3 | " | Nookachamps sil | 0-3 | " | Skokomish sil | 0-3 | " |
| Cokedale sil/Puyallup | 0-3 | " | Puget sicl* | 0-3 | " | Snohomish sicl | 0-3 | " |
| Cokedale sil | 0-3 | " | Puget cl | 0-3 | " | Snohomish l | 0-3 | " |
| Cokedale l | 0-3 | " | Puget l | 0-3 | " | Snohomish sil | 0-3 | " |
| Lummi sil | 0-3 | " | Puget sil | 0-3 | " | Snohomish fsl | 0-3 | " |
| Lummi fsl | 0-3 | " | Puget fsl | 0-3 | " | Snohomish lfs | 0-3 | " |
| Maytown sil | 0-3 | " | Puget vfsl | 0-3 | " | Snohomish sic | 0-3 | " |
| Maytown sicl | 0-3 | " | Samish sicl | 0-3 | " | | | |

Land Capability Unit IIws06 (IIw4) consists of deep, very poorly drained organic soils formed from sedges, woody and other organic materials in closed basins of bottom lands and uplands.

Organic soils have continuing wetness and soil management problems. Where drained, the soils settle about 1 inch per year. Generally, drained and fertilized organic soils are highly productive and well suited for growing hay and pasture, row crops, vegetables, and forage crops. These organic soils are well suited for irrigation. Their water intake rates are moderate and their water-holding capacities are high.

| Mapping Unit | % Slope | ADP Code | Mapping Unit | % Slope | ADP Code | Mapping Unit | % Slope | ADP Code |
|---|---|---|---|---|---|---|---|---|
| Carbondale muck | 0-3 | 22306 | McMurray peat | 0-3 | 22306 | Semiahmoo muck* | 0-3 | 22306 |
| Mukilteo peat | 0-3 | " | Rifle peat | 0-3 | " | | | |

Table 11. Crop yields by land capability units in Puget Sound Area (con.)

| Typical soil type for capability unit | Land capability unit | Crops and yields | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Hay, grass & legumes | | Hay, alfalfa | | Pasture | | Silage | | Small grain | | Potatoes | | Peas | | Pole beans | | Sweet corn | | Broccoli | | Strawberries | | Cane berries | |
| | | Tons | | Tons | | AUM | | Tons | | Tons | | Tons | | Tons | | Tons | | Tons | | Tons | | Tons | | Tons | |
| | | A | B | A | B | A | B | A | B | A | B | A | B | A | B | A | B | A | B | A | B | A | B | A | B |
| Kickerville silt loam 8-15% | IVes6 | 1.0 | 5.0 | | | 2.25 | 11.75 | 5.1 | 15.5 | 0.5 | 1.0 | 7.0 | 12.0 | | | | | | | | | | | | |
| Sol Duc gravelly loam 8-15% | IVes7 | | 4.5 | | | | 10.5 | | 13.9 | | 1.75 | | | | | | | | | | | 3.0 | 3.8 | | |
| Skiyou gravelly loam | IVes8 | 1.75 | 2.25 | | | 4.25 | 5.25 | 5.4 | 7.0 | | | | | | | | | | | | | | | | |
| Shelton gravelly sandy loam 8-15% | IVes9 | 2.0 | 8.0 | 2.7 | | 4.75 | 19.0 | 6.2 | 24.8 | 0.6 | | | | | | | | | | | | 1.5 | 2.0 | | |
| Townsend sandy loam | IVes10 | 4.5 | 7.5 | | 3.0 | 10.75 | 17.75 | 13.9 | 23.2 | | 1.0 | | | | | | | | | | | | | | |
| San Juan gravelly sandy loam 8-15% | IVes11 | 0.5 | 1.5 | 1.4 | 1.7 | 1.25 | 3.5 | | 4.6 | 0.3 | 0.7 | | | | | | | | | | | | | | |
| Heisler shaly loam | IVes13 | 2.0 | 4.0 | | | 4.75 | 9.5 | 6.2 | 12.4 | | | | | | | | | | | | | | | | |
| Melbourne silty clay loam | IVes16 | 2.0 | 2.5 | | | 4.75 | 6.0 | 6.2 | 7.0 | 0.4 | 0.6 | | | | | | | | | | | | | | |
| Sinclair shotty loam | IVew3 | 1.75 | 2.5 | 2.5 | 2.8 | 4.25 | 6.0 | 5.4 | 7.75 | 0.8 | 0.4 | | | | | | | | | | | 1.3 | 2.2 | | |
| Whatcom silt loam 8-15% 3-8% | IVew12& IIIwe16 | 3.0 | 7.0 | | | 7.0 | 16.5 | 9.3 | 21.7 | 0.5 | 1.0 | | | | | | | | | | | | | | |
| Kitsap silty clay loam 8-15% | IVew14 | 2.0 | 5.0 | | | 4.75 | 11.75 | 6.2 | 15.5 | | | | | | | | | | | | | | | | |
| Alderwood gravelly sandy loam | IVew22 | 1.75 | 5.0 | | | 4.25 | 12.0 | 5.4 | 15.5 | | | | | | | | | | | | | 2.0 | 4.0 | 3.0 | 6.0 |
| Lynden sandy loam 3-8% | IVs1 | 1.5 | 6.0 | | | 3.5 | 14.22 | 4.6 | 18.6 | 0.5 | 2.0 | | 15.0 | | | | | | | | | 3.0 | 7.0 | | |
| Lynden sandy loam 8-15% | IVs5 | 1.5 | 6.0 | | | 3.5 | 14.25 | 4.6 | 18.6 | 0.5 | 2.0 | | 15.0 | | | | | | | | | | 7.0 | | |
| Spanaway gravelly sandy loam | IVs10 | 1.5 | 2.5 | | | 3.5 | 6.0 | 4.6 | 7.75 | 0.3 | 2.0 | | | | | | | | | | | | | | |
| National pumicy sandy loam | IVs12 | 1.75 | 3.0 | | | 4.25 | 7.0 | 5.4 | 9.3 | 0.7 | 1.0 | | | | | | | | | | | | | | |
| Indianola fine sandy loam 8-15% | IVse05 | 1.5 | 6.0 | | | 3.5 | 14.25 | 4.6 | 18.6 | 0.5 | 2.0 | | 15.0 | | | | | | | | | 3.0 | 7.0 | | |
| Ragnar fine sandy loam 8-15% | IVse13 | 1.5 | 6.0 | | | 3.5 | 14.25 | 4.6 | 18.6 | 0.5 | 2.0 | | 15.0 | | | | | | | | | | 7.0 | | |
| Whidbey gravelly sandy loam 3-8% | IVsw6 | 3.0 | 7.5 | | | 7.0 | 14.25 | 9.3 | 18.6 | | | | | | | | | | | | | | | | |
| Alderwood gravelly sandy loam 3-8% | IVsw9 | 1.75 | 3.5 | | | 4.25 | 8.25 | 5.4 | 10.8 | | | | | | | | | | | | | 2.0 | 4.0 | 3.0 | 6.0 |
| Pilchuck fine sandy loam | IVws1 | 0.75 | 1.0 | | | 1.75 | 2.25 | | 3.1 | | | | | | | | | | | | | | | | |
| Puget clay | IVws5 | 1.0 | 2.0 | | | 2.35 | 4.75 | 3.1 | 6.2 | | | | | | | | | | | | | | | 4.0 | 5.0 |
| Semiahmoo muck, shallow | IVws6 | 3.25 | 4.0 | | | 7.75 | 9.5 | 10.0 | 12.4 | 1.1 | 1.9 | | | | | | | | | | | | | | |
| Schooley loam | IVws7 | 2.5 | 3.0 | 3.5 | | 6.0 | 7.0 | 7.75 | 9.3 | | | | | | | | | | | | | | | | |
| Koch silt loam | IVws8 | 3.0 | 5.0 | | | 7.0 | 12.0 | 9.3 | 15.5 | 0.6 | | | | 1.0 | | | | | | | | | | 1.8 | |
| McKenna gravelly loam | IVws9 | 3.5 | 4.5 | | | 8.25 | 10.75 | 10.8 | 13.9 | | | | | | | | | | | | | | | | |
| Bellingham silty clay | IVws10 | 2.5 | 5.0 | | | 6.0 | 12.0 | 7.75 | 15.5 | | | | | | | | | | | | | | | | |
| Bow gravelly loam | IVws11 | 1.5 | 4.0 | | | 3.5 | 9.5 | 4.6 | 12.4 | 0.06 | 1.75 | | | | | | | | | | | | | | |
| Agnew silty clay loam | IVws13 | 5.0 | 8.0 | | | 11.75 | 19.0 | 15.5 | 24.8 | 1.0 | 2.0 | | | 1.0 | 3.0 | | | | 6.0 | | | | | | |
| Bozarth fine sandy loam | IVws43 | 2.5 | 4.0 | | | 6.0 | 9.5 | 7.75 | 12.4 | 0.06 | | | | | | | | | | | | | | | |

Land Capability Unit IIws09 (IIw5) consists of medium and moderately coarse textured somewhat poorly drained soils with slowly permeable subsoils occurring on gently sloping terraces.

Management problems in the use of this group are primarily, wetness, and secondarily, soils. Improved land drainage provides an environment suited for growing grasses and legumes for hay and pasture, silage, small grains, vegetables, hops, and cane berries. These soils are suited for continuous cropping, with the use of winter cover crops and green manure. They are also suited for growing hay and pasture 5 to 10 years, followed by row crops 1 to 2 years, with winter cover crops between successive years of row crops; or hay and pasture 5 to 10 years followed by cane fruits with annual cover crops 7 to 10 years. Crop yields are moderate to high under a high level of management. The soils are well suited for sprinkler irrigation; and irrigation during the dry summer season materially increases crop yields.

| Mapping Unit | % Slope | ADP Code | Mapping Unit | % Slope | ADP Code | Mapping Unit | % Slope | ADP Code |
|---|---|---|---|---|---|---|---|---|
| Orting l* | 0-3 | 22309 | Orting sl | 0-3 | 22309 | Sultan sil, shallow/Buckley | 0-3 | 22309 |

Land Capability Unit IIws12 (IIw6) consists of gently sloping upland terraces which have a problem of wetness due to ponding. They have silt loam surfaces and sandy loam subsoils overlying dense clay marine and glacial sediments.

Management problems in the use of this group are primarily, wetness, and secondarily, soils. Except in low wet areas, the soils are well suited for growing grass and legumes for hay and pasture and for growing alfalfa. They are fairly well suited for growing small grains and vegetable crops. The soils are well suited for continuous cropping, provided green manures are used during winter seasons. They are suited for growing hay and pasture 5 to 10 years, followed by row crops 1 to 2 years, with winter cover crops between successive years of row crops. Crop yields are moderate to moderately high under a high level of conservation management.

| Mapping Unit | % Slope | ADP Code | Mapping Unit | % Slope | ADP Code | Mapping Unit | % Slope | ADP Code |
|---|---|---|---|---|---|---|---|---|
| Coupeville l | 0-3 | 22312 | Coupeville sil* | 0-3 | 22312 | | | |

Land Capability Unit IIs01 (IIs1) consists of moderately deep and medium textured soils on nearly level to gently sloping uplands. The soils have a high content of volcanic ash.

Maintenance of soil productivity is the primary conservation management problem on the soils of this unit. The soils are well suited for growing strawberries, cane berries, vegetables, row crops, bulbs, small grains, forage, alfalfa, grasses and legumes for hay and pasture, and wood crops. The soils are suited for continuous cropping when winter cover crops, green manures, all available barnyard manure, and complete commercial fertilizers, are used. Also, they are suited for growing hay and pasture 3 to 4 years with strawberries 3 to 4 years; or hay and pasture 5 to 10 years followed by row crops, vegetables, or bulbs 1 to 2 years, with winter cover crops between successive years of row crops; or hay and pasture 5 to 10 years followed by cane fruits with annual cover crops 7 to 10 years. Crop yields are moderate to high under an intensive conservation management program.

| Mapping Unit | % Slope | ADP Code | Mapping Unit | % Slope | ADP Code | Mapping Unit | % Slope | ADP Code |
|---|---|---|---|---|---|---|---|---|
| Cinebar sil | 0-3 | 23001 | Giles sil* | 3-8 | 23001 | Salal sil | 0-3 | 23001 |
| Giles sil | 0-3 | " | | | | | | |

Land Capability Unit IIsw02 (IIs2) consists of gently sloping, deep terrace soils, with medium and moderately coarse textured surfaces and moderately fine textured subsoils.

Conservation management problems on this group of soils are maintenance of productivity and slight internal wetness. The soils are suited for growing grass and legumes, small grains, potatoes, strawberries, cane berries and wood crops. They are suited for continuous cropping by using winter cover crops, green manures, all available barnyard manure, and complete commercial fertilizers. Also, they are suited for growing hay and pasture, grass and legumes, 3 to 4 years followed by strawberries 3 to 4 years; or hay and pasture 5 to 10 years followed by row crops, potatoes, or bulbs 1 to 3 years, with winter cover crops between successive years of row crops; or cane fruits with annual cover crops 7 to 10 years. Crop yields are moderate to high under an intensive conservation management program. Windthrow is a moderate hazard to woodlands on these soils because of the dense silty clay loam subsoils which prevent root penetration to depths sufficient to support the trees. Crops grown on these soils respond well to treatment of barnyard manure and complete commercial fertilizers mixed to meet the requirements for specified crops. Lime applications may be beneficial to establishment and maintenance of the legumes and legume-grass mixtures.

| Mapping Unit | % Slope | ADP Code | Mapping Unit | % Slope | ADP Code | Mapping Unit | % Slope | ADP Code |
|---|---|---|---|---|---|---|---|---|
| Agnew l* | 0-3 | 23202 | Agnew fsl | 3-8 | 23202 | | | |

Land Capability Unit IIsw03 (IIs3) consists of moderately deep, well drained moderately coarse textured soils on gentle slopes.

The conservation management problems are maintenance of productivity and local internal wetness. The soils are well suited for growing strawberries, cane berries, vegetables, peas, row crops, bulbs, small grains, forage, grasses and legumes for hay and pasture, and wood crops. These soils are suited for continuous cropping when winter cover crops, green manures and all available barnyard manure and complete commercial fertilizers are used. Also, they are suited for growing hay and pasture 3 to 4 years with strawberries 3 to 4 years; or hay and pasture 5 to 10 years with row crops, vegetables, peas or bulbs 1 to 2 years; or cane fruits with annual cover crops 7 to 10 years. Crop yields are moderate under an intensive conservation management program. Generally, most of these soils are under cultivation and are not used for wood crops. If they should be used for wood crops their production would be only moderate. Other crops grown on these soils respond well to treatment of barnyard manure and complete commercial fertilizers mixed to meet the requirements for specified crops. Lime applications may be beneficial to the establishment and maintenance of legumes and legume-grass mixtures.

Land Capability Unit IIsw03 (IIs3) (Con.)

| Mapping Unit | % Slope | ADP Code | Mapping Unit | % Slope | ADP Code | Mapping Unit | % Slope | ADP Code |
|---|---|---|---|---|---|---|---|---|
| Ebeys sl* | 0-3 | 23203 | Ebeys sl | 3-8 | 23203 | | | |

Land Capability Unit IIIew01 (IIIe1) consists of deep and moderately deep, moderately well drained glacial terraces on undulating topography. Their surfaces are medium textured, their subsoils are medium to moderately fine textured, and their substrata are cemented very gravelly sandy loams or sands.

The conservation management problems are primarily erosion control and drainage of low, wet areas. The soils are well suited for growing row crops, vegetables, strawberries, small grains, forage, grasses, legumes and wood crops. Adequate protection against accelerated erosion, maintenance of soil structure and productivity may be accomplished by growing grass and legume cover for 4 to 5 years, followed by 1 to 4 years of row crops, with winter cover crops between successive years of row crops; hay and pasture 3 to 4 years with strawberries 3 to 4 years; or hay and pasture 5 to 10 years with row crops 1 to 2 years. Crops grown on these soils produce average to high yields. The crops respond well to use of available barnyard manure with complete commercial fertilizer mixed to meet specific crop needs. Lime and fertilizer requirements for establishment and maintenance of crops can be determined by soil tests. Crops grown on soils of this management unit respond well to irrigation. The soil water intake rates are moderate, and their water-holding capacities are low. These soils have a good site index rating for growing Douglas-fir. Windthrow is a moderate hazard on these moderately deep soils over cemented glacial till. Douglas-fir saplings have severe competition from deciduous trees and brush unless the site is intensively managed.

| Mapping Unit | % Slope | ADP Code | Mapping Unit | % Slope | ADP Code | Mapping Unit | % Slope | ADP Code |
|---|---|---|---|---|---|---|---|---|
| Alderwood l | 0-8 | 31201 | Cagey sl | 0-8 | 31201 | Coveland sil | 0-8 | 31201 |
| Alderwood sil | 0-8 | " | Cagey sil | 0-8 | " | Kitsap l | 3-8 | " |
| Cagey gfsl | 3-8 | " | Coveland l | 3-8 | " | Kitsap sil* | 3-8 | " |
| Cagey gl | 0-8 | " | Coveland gl | 3-8 | " | Nesika l | 0-8 | " |
| Cagey gsl | 0-8 | " | Coveland gsil | 3-8 | " | Roche l | 0-8 | " |

Land Capability Unit IIIew03 (IIIe2) consists of moderately deep, moderately well drained glacial terrace soils on undulating and rolling topography. Their surfaces consist of loams, gravelly loams and sandy loams; their subsoils are gravelly loams and silty clay loams; and their substrata are dense or cemented gravelly loams, silts and clays.

The soils are well suited for growing grasses, legumes, small grains, potatoes and wood crops. Adequate protection against accelerated erosion, maintenance of soil structure and productivity may be accomplished by growing grass and legume crops 4 to 5 years, followed by 1 to 4 years of row crops, with winter cover crops between successive years of row crops; hay and pasture 3 to 4 years with strawberries 3 to 4 years; or hay and pasture 5 to 10 years with row crops 1 to 2 years. Crops grown on these soils produce average to high yields. Crops respond well to irrigation during periods of low precipitation.

| Mapping Unit | % Slope | ADP Code | Mapping Unit | % Slope | ADP Code | Mapping Unit | % Slope | ADP Code |
|---|---|---|---|---|---|---|---|---|
| Agnew sl | 8-15 | 31203 | Clallam gl | 3-8 | 31203 | Clallam l* | 3-8 | 31203 |

Land Capability Unit IIIes02 (IIIe3) consists of moderately deep and deep, medium and moderately fine textured, well drained soils formed on gently sloping glacial upland terraces. The substratum is compact glacial till or sandstone.

Conservation management problems are primarily, erosion control, and secondarily, maintenance of soil productivity. The soils are well suited for growing row crops, vegetables, strawberries, small grains, forage, grasses, legumes, and wood crops. Adequate protection against accelerated erosion, maintenance of soil structure and productivity can be accomplished by growing grasses and legumes 5 to 10 years, followed by 1 to 4 years of row crops with winter cover crops between successive years of row crops; or grasses and legumes 3 to 4 years with strawberries 3 to 4 years. Crops grown on these soils produce average to high yields, and respond well to irrigation during seasons of low precipitation. Suitability of the soils for growing Douglas-fir is good to very good, with site indexes ranging from 130 to 170. Brush competition is moderate. Susceptibility to windthrow is slight on the deep soils and moderate on soils 20 to 30 inches deep. Generally, logging equipment limitations are only moderate.

| Mapping Unit | % Slope | ADP Code | Mapping Unit | % Slope | ADP Code | Mapping Unit | % Slope | ADP Code |
|---|---|---|---|---|---|---|---|---|
| Cathcart l* | 3-8 | 31302 | Cathcart gsil | 3-8 | 31302 | Sauk l | 3-8 | 31302 |
| Cathcart cl | 3-8 | " | Delphi gl | 8-15 | " | Saxon sil | 3-8 | " |
| Cathcart fsl | 3-8 | " | Giles l | 3-8 | " | Wickersham shaly sil | 3-8 | " |

Land Capability Unit IIIwe16 (IIIw1) consists of somewhat poorly drained and medium textured soils with compact, fine textured subsoils and substrata.

Conservation management problems are primarily wetness, and secondarily, erosion. These soils, where drained, are well suited for growing grasses, legumes, small grains, forage, annual row crops, and strawberries. Adequate soil protection may be attained by growing grass and legumes 5 to 10 years with 1 or 2 years of oats; grass and legumes 4 or 5 years with not more than 3 to 4 years of forage (corn); or row crops and winter cover crops between successive years of row crops. Crop yields are moderate under a conservation management program. Crops respond well to applications of manures and complete commercial fertilizers mixed to meet the requirements of each crop. The fertilizer and lime requirements of these soils may best be determined by soil tests. Crops respond well to supplemental irrigation during periods of low precipitation. Excess water caused by overirrigation may cause crop damage by waterlogging of the root zone above the restrictive zone. Likewise, a waterlogged soil may cause seep spots to develop in low lying areas by water moving laterally over restrictive layers. The problem may be corrected by reducing water applications, but should the problem extend over a wide area, correction may be by water interception ditches and tile to provide extra drainage capacity to promptly dispose of the excess water. Soils of this management unit are very well suited for growing Douglas-fir. However, they have moderate to severe equipment limitations due to seasonal wetness when the soils may become quick. Windthrow may be a moderate to severe hazard where depths over dense glacial till are 24 to 36 inches.

Land Capability Unit IIIwe16 (IIIw1) (Con.)

| Mapping Unit | % Slope | ADP Code | Mapping Unit | % Slope | ADP Code | Mapping Unit | % Slope | ADP Code |
|---|---|---|---|---|---|---|---|---|
| Whatcom sil* | 0-8 | 32116 | Bow gsil | 0-8 | 32116 | | | |

Land Capability Unit IIIwe17 (IIIw2) consists of upland terrace soils that are moderately shallow to shallow (12 to 36 inches deep), and poorly to somewhat poorly drained. The soils have medium and moderately coarse textured surfaces, and moderately coarse to moderately fine textured subsoils which overlie dense glacial till.

The primary conservation management problem is wetness, and the secondary problem is stabilization against erosion. The soils are suited for growing grasses, legumes, small grains, strawberries, and cane berries. They may be adequately protected against erosion losses and deterioration by growing grass and legumes 4 to 10 years with 1 or 2 years of small grains; grass and legumes 3 to 4 years with strawberries 3 to 4 years; or grass and legumes 5 to 10 years with cane fruits, and winter cover crops 7 to 10 years. Under a high level of conservation management, yields on these soils are moderate to high. The soils are suitable for irrigation during periods of low precipitation. Without drainage, these soils are best suited for growing wetland grasses and legumes, with small grains used periodically as cleanup crops. The soils, with site index ratings ranging between 140 and 160, rate as good for Douglas-fir production. Equipment limitations are moderate to severe. The soils may become quick when they are wet; therefore, the use of logging equipment may be limited to periods when the soils are not saturated. Logging equipment moving over saturated soils destroys soil structure, which results in slower drainage and causes a soil-moisture-air environment better suited for brush species than for regeneration of Douglas-fir.

| Mapping Unit | % Slope | ADP Code | Mapping Unit | % Slope | ADP Code | Mapping Unit | % Slope | ADP Code |
|---|---|---|---|---|---|---|---|---|
| Enumclaw l | 3-8 | 32117 | Kapowsin gl | 3-8 | 32117 | Kapowsin gsl | 3-8 | 32117 |
| Kapowsin gcl* | 3-8 | " | | | | | | |

Land Capability Units IIIws01, 02 (IIIw3) consist of moderately deep, well drained and somewhat excessively drained bottom lands subject to periodic overbank flow flooding and sedimentation. Their surfaces consist of medium to moderate or moderately fine textures.

The primary conservation management problem is overbank flow flooding, and the secondary problem is maintenance of soil productivity. The soils are well suited for growing grasses, legumes, alfalfa, pole beans, sweet corn, strawberries, and cane berries. High yields can be maintained under an intensive conservation management program. Productivity and protection of these soils can be attained by continuous row cropping with winter cover crops between successive years of row crops; growing grass and legumes 4 to 10 years, followed by 1 to 4 years of row crops, with winter cover crops between successive years of row crops; growing grasses and legumes 5 to 10 years, with strawberries 3 to 4 years; or by growing grasses and legumes 5 to 10 years, with cane fruits and winter cover crops 7 to 10 years. Any combination of the above outlined conservation measures is designed to protect the soil against deterioration and to provide average to high yields. Irrigation during periods of low rainfall promotes continued crop growth and increases production. Crops respond well to the use of all available barnyard manure, and to the use of complete commercial fertilizers mixed to meet specific crop needs. The fertilizer requirements for crops on each soil depend upon past management.

| Mapping Unit | % Slope | ADP Code | Mapping Unit | % Slope | ADP Code | Mapping Unit | % Slope | ADP Code |
|---|---|---|---|---|---|---|---|---|
| Belfast fsl | 0-3 | 32301 | Edgewick fsl | 0-3 | 32301 | Kline l | 0-3 | 32302 |
| Belfast sl | 0-3 | " | Eld sil | 0-3 | " | Kline l | 3-8 | " |
| Belfast sil | 0-3 | " | Eld l | 0-3 | 32302 | Kline sil* | 0-3 | " |
| Camas gl | 0-3 | " | Eld gl | 0-3 | " | Newberg fsl | 0-3 | 32301 |
| Cokedale sl | 0-3 | " | Eld sicl | 0-3 | " | Newberg l | 0-3 | " |
| Cokedale sicl/Puyallup | 0-3 | " | Kline gl | 0-3 | " | Puyallup fsl* | 0-3 | " |
| Dungeness fsl, shallow | 0-3 | " | Kline gl | 3-8 | " | Puyallup sl | 0-3 | " |
| Edgewick vfsl | 0-3 | " | | | | | | |

Land Capability Unit IIIws03 (IIIw4) consists of nearly level, deep and moderately deep (20-40 inches), medium, moderately fine, and moderately coarse textured bottom land soils. Their surfaces consist of medium to moderately fine textures which are medium to strongly acid.

Conservation management problems are primarily, wetness due to flooding by streambank overflow, and secondarily, soil productivity maintenance. Flood prevention and improved land drainage make these soils fairly well suited for growing row crops, vegetables, peas, sweet corn, grasses, legumes, and small grains. The soils can be protected against deterioration and productivity can be maintained by continuous row cropping with winter cover crops between successive years of row crops; growing grasses and legumes 4 to 10 years followed by row crops 1 to 4 years, with winter cover crops between successive years of row crops; growing grasses and legumes 3 to 4 years with strawberries 3 to 4 years; or growing grasses and legumes 5 to 10 years with cane fruits and winter cover crops 7 to 10 years. Crop yields are moderately high under such a system of conservation management. Irrigation is well suited to these lands during periods of low precipitation.

| Mapping Unit | % Slope | ADP Code | Mapping Unit | % Slope | ADP Code | Mapping Unit | % Slope | ADP Code |
|---|---|---|---|---|---|---|---|---|
| Cokedale sicl | 0-3 | 32303 | Maytown fsl | 0-3 | 32303 | Puyallup sl/Buckley substrata material | 0-3 | 32303 |
| Lummi sicl* | 0-3 | " | Nuby sil | 0-3 | " | | | |

Land Capability Unit IIIws04 (IIIw5) occurs on gently sloping to gently undulating topography with slope gradients ranging between 1 and 8 percent. The surface soils consist of medium and moderately coarse textures with a reaction which ranges from pH 5.6 to 6.5. The substrata consist of moderately coarse dense basal till.

Conservation management problems are primarily, wetness, and secondarily, soil productivity maintenance. The soils are suited for growing grasses, legumes, small grains, peas, and strawberries. The land may be protected against deterioration by growing grasses and legumes 4 to 10 years, followed by row crops 1 to 4 years, with winter cover crops between successive years of row crops; grasses and legumes 3 to 4 years with strawberries 3 to 4 years; or grasses and legumes, 4 to 10 years followed by small grains or forage crops 1 to 4 years, with winter cover crops between successive years of row crops. These soils are suitable for sprinkler irrigation during periods of low precipitation. Crops respond well to irrigation. Supplemental irrigation during periods of moisture deficiencies, where fertilizers are used, will usually increase crop yields to near their potential.

| Mapping Unit | % Slope | ADP Code | Mapping Unit | % Slope | ADP Code | Mapping Unit | % Slope | ADP Code |
|---|---|---|---|---|---|---|---|---|
| San Juan gsl, moderately deep | 3-8 | 32304 | San Juan l, moderately deep | 3-8 | 32304 | Sequim cl | 0-3 | 32304 |
| | | | | | | Sequim gl* | 0-3 | " |

Land Capability Unit IIIws05 (IIIw6) consists of poorly drained, moderately shallow (20 to 30 inches), moderately fine textured bottom land soils on nearly level topography. The soils have medium to strongly acid silt loam, clay loam and silty clay loam surfaces, with silty clay loam, clay loam and clay subsoils overlying clay substrata.

The primary conservation management problem is wetness, and the secondary problem is maintenance of soil productivity. These soils are best suited for growing grasses, legumes, corn, peas and broccoli. Yields are moderate, and limited by wetness and shallow rooting depths. Soils of this land class can be adequately maintained by growing grasses and legumes 4 to 10 years, followed by small grains 1 or 2 years; grasses and legumes 5 to 10 years with row crops (corn, peas or broccoli) 1 to 2 years; including a winter cover crop between successive years of row crops. Crop yields are moderate under a high level conservation management program. Without drainage, the soils are best suited for growing wetland grasses and legumes. Sprinkler irrigation during dry summer periods materially increases crop production. Supplemental irrigation during periods of moisture deficiencies, where fertilizers are used, will usually increase crop yields to near their potential.

| Mapping Unit | % Slope | ADP Code | Mapping Unit | % Slope | ADP Code | Mapping Unit | % Slope | ADP Code |
|---|---|---|---|---|---|---|---|---|
| Alluvial soils, undifferentiated | 0-3 | 32305 | Wapato cl | 0-3 | 32305 | Wapato sil-Galvin sil complex | 0-3 | 32305 |
| | | | Wapato sil | 0-3 | " | | | |
| Issaquah sil | 0-3 | " | Wapato sicl | 0-3 | " | Woodinville sil | 0-3 | " |
| Sammamish sil* | 0-3 | " | | | | | | |

Land Capability Unit IIIws08 (IIIw7) consists of moderately shallow, poorly drained soils with iron cemented subsoils which occur on nearly level basin-like topography of glacial outwash terraces.

Conservation management problems are primarily, wetness, and secondarily, maintenance of soil productivity. Where drained, the soils are suited for growing grasses, legumes, small grains, silage, and strawberries. Conservation measures necessary to maintain soil structure and productivity consist of growing grasses and legumes 3 to 4 years, with strawberries 3 to 4 years; grasses and legumes 4 to 5 years, with silage and forage crops 1 to 2 years; annual green manure crops between successive years of silage crops; or grasses and legumes 5 to 10 years with small grains 1 year. Crop yields range from moderately low to moderately high under a conservation management program. Limestone, available barnyard manure, and complete commercial fertilizers are beneficial in establishing and maintaining crops on these soils. Crops respond well to supplemental irrigation during the dry summer season. Irrigation during periods of moisture deficiencies, where fertilizers are used, will usually increase crop yields to near their potential.

| Mapping Unit | % Slope | ADP Code | Mapping Unit | % Slope | ADP Code | Mapping Unit | % Slope | ADP Code |
|---|---|---|---|---|---|---|---|---|
| Custer fsl | 0-3 | 32308 | Edmonds-Tromp sil | 0-3 | 32308 | Tromp-Tisch fsl complex | 0-3 | 32308 |
| Custer sl | 0-3 | " | Giles-Tromp sil | 0-3 | " | | | |
| Custer sil | 0-3 | " | Hale sil | 3-8 | " | Tromp-Custer sil | 0-3 | " |
| Edmonds l | 0-3 | " | Hale-Norma sil | 0-3 | " | Tromp-Edmonds sil complex | 0-3 | " |
| Edmonds sil | 0-3 | " | Tromp sil | 0-3 | " | | | |
| Edmonds sl* | 0-3 | " | Tromp fsl | 0-3 | " | Tromp-Woodlyn sil | 0-3 | " |
| Edmonds fsl | 0-3 | " | Tromp sicl | 0-3 | " | Woodlyn sil | 0-3 | " |

Land Capability Unit IIIws09 (IIIw8) consists of moderately deep (20 to 36 inches), poorly drained soils, which occur on basin-like topography with slopes of less than 5 percent.

The primary conservation management problem is wetness, and the secondary problem is maintenance of soil productivity. Where drained, the soils are suited for growing grasses and legumes for hay and pasture, and for the production of silage. Under a high level of conservation management, yields are moderate. Conservation measures required to maintain production consist of growing grasses and legumes for hay and pasture 5 to 10 years, with small grains or row crops to reestablish grasses and legume stands, 1 to 2 years. Where drained, and during periods of low precipitation, these soils are suited for sprinkler irrigation. Supplemental irrigation, where fertilizers are used, will usually increase crop yields to near their potential.

| Mapping Unit | % Slope | ADP Code | Mapping Unit | % Slope | ADP Code | Mapping Unit | % Slope | ADP Code |
|---|---|---|---|---|---|---|---|---|
| Galvin sil | 0-3 | 32309 | Norma-Hale sil | 0-3 | 32309 | Norma sil | 3-8 | 32309 |
| Galvin sicl | 0-3 | " | Norma l* | 0-3 | " | Norma sic | 0-3 | " |
| Norma-Cagey sil | 0-3 | " | Norma l | 3-8 | " | Norma sicl | 0-3 | " |
| Norma cl | 0-3 | " | Norma sl | 0-3 | " | Orting gsl | 0-3 | " |
| Norma fsl | 0-3 | " | Norma sil | 0-3 | " | | | |

Land Capability Unit IIIws10 (IIIw9) consists of moderately shallow soils 20 to 40 inches deep, which occur on nearly level basin topography with slope gradients of less than 3 percent.

Management problems are wetness and maintenance of soil productivity. The soils are best suited for growing grasses and legumes for hay and pasture, or for the production of forage in the form of silage. Conservation measures for maintaining the land consist of growing hay and pasture 5 to 10 years with 1 or 2 years of small grains, or hay and pasture (grasses and/or legumes) 5 to 10 years, with not more than 3 or 4 years of peas or corn, including cover crops between successive years of row crops. Without drainage, soils of this management group are suited for growing wetland grasses and legumes. The soils are suitable for sprinkler irrigation during periods of low precipitation, and supplemental irrigation during periods of moisture deficiencies, where fertilizers are used, will usually increase crop yields to near their potential.

| Mapping Unit | % Slope | ADP Code | Mapping Unit | % Slope | ADP Code | Mapping Unit | % Slope | ADP Code |
|---|---|---|---|---|---|---|---|---|
| Bellingham cl | 0-3 | 32310 | Buckley-Enumclaw l | 0-3 | 32310 | Labounty-McKenna sicl complex | 0-3 | 32310 |
| Bellingham fsl | 0-3 | " | Clackamas sicl | 0-3 | " | | | |
| Bellingham l | 0-3 | " | Clipper sicl | 0-3 | " | McKenna sicl | 0-3 | " |
| Bellingham sil | 0-3 | " | Coveland l | 0-3 | " | Rifle (McMurray) peat-Bellingham sicl (called complex peat) | 0-3 | " |
| Bellingham sil | 3-8 | " | Coveland gl | 0-3 | " | | | |
| Bellingham sicl* | 0-3 | " | Coveland gsil | 0-3 | " | | | |
| Bellingham sicl | 3-8 | " | Coveland sil | 0-3 | " | | | |
| Buckley l | 0-3 | " | Everson sil | 0-3 | " | Tisch sil | 0-3 | " |
| Buckley sil | 0-3 | " | Everson fsl | 0-3 | " | Tisch sicl | 0-3 | " |

Land Capability Unit IIIws11 (IIIw10) consists of poorly and imperfectly drained soils 20 to 30 inches deep, underlain by dense glacial clay basal till. The soils occur on nearly level topography with slope gradients of less than 3 percent.

Management problems are wetness and maintenance of soil productivity. These soils are best suited for growing grasses and legumes for hay and pasture, or for the production of forage in the form of silage. Adequate conservation measures for protection against deterioration may be attained by growing hay and pasture for 5 years, with 1 or 2 years of oats; or hay and pasture 4 to 5 years, with not more than 3 to 4 years of peas or corn, including winter cover crops between successive years of row crops. Without drainage, these soils are suited for growing wetland grasses and legumes. The soils are suitable for sprinkler irrigation during periods of low precipitation, and supplemental irrigation during periods of moisture deficiencies, where fertilizers are used, will usually increase crop yields to near their potential.

| Mapping Unit | % Slope | ADP Code | Mapping Unit | % Slope | ADP Code | Mapping Unit | % Slope | ADP Code |
|---|---|---|---|---|---|---|---|---|
| Bow gsil, low rainfall phase | 0-3 | 32311 | Casey sil | 0-3 | 32311 | Hemmi sil* | 0-3 | 32311 |

Land Capability Unit IIIws12 (IIIw11) consists of upland terrace soils which generally are moderately shallow (20 to 30 inches deep), and poorly to somewhat poorly drained. The soils occur on gently sloping topography with slope gradients of less than 3 percent. They have medium, moderately fine and moderately coarse textured surfaces, and moderately coarse to moderately fine textured subsoils which overlie dense glacial till or clay substrata.

Management problems are wetness and maintenance of soil productivity. The soils are suited for growing grasses and legumes for hay and pasture, silage, and strawberries. Adequate protection against deterioration from erosion and fertility depletion can be attained by growing grasses and legumes 4 to 10 years, with small grains 1 to 2 years; or grasses and legumes 5 to 10 years, with row crops (peas or corn) not more than 3 to 4 years, and winter cover crops between successive years of row crops. Without drainage, these soils are best suited for growing wetland grasses and legumes. The soils are suitable for sprinkler irrigation during seasons of low precipitation, and supplemental irrigation during periods of moisture deficiencies, where fertilizers are used, will usually increase crop yields to near their potential.

| Mapping Unit | & Slope | ADP Code | Mapping Unit | % Slope | ADP Code | Mapping Unit | % Slope | ADP Code |
|---|---|---|---|---|---|---|---|---|
| Cagey gfsl | 0-3 | 32312 | Enumclaw fsl | 0-3 | 32312 | Labounty sil | 0-3 | 32312 |
| Cagey gsl | 0-3 | " | Enumclaw gsl | 0-3 | " | Nesika l | 0-3 | " |
| Cagey sil-Norma sicl complex | 0-3 | " | Kapowsin gl | 0-3 | " | Puyallup-Buckley fsl | 0-3 | " |
| | | | Kitsap sil* | 0-3 | " | Waddell sicl | 0-3 | " |
| Enumclaw l | 0-3 | " | | | | | | |

Land Capability Unit IIIs01 (IIIs1) consists of glacial terraces and alluvial fans with nearly level to undulating topography (0-8 percent slopes). The soils have loam and silt loam surfaces, and loam, sandy loam or loamy sand subsoils overlying sands, gravelly sands or shale substrata.

The primary management problem is maintenance of soil productivity. The soils are suited for growing grasses, legumes, small grains, corn, potatoes, strawberries, and cane fruits. Adequate protection against soil deterioration can be attained by growing grasses and legumes 5 to 10 years with 1 or 2 years of small grains; grasses and legumes 4 to 5 years with not more than 3 to 4 years of row crops, potatoes or corn, and winter cover crops between successive years of row crops; grasses and legumes 3 to 4 years, followed by strawberries 3 to 4 years; or grasses and legumes 5 to 10 years followed by cane fruits, with winter cover crops 7 to 10 years. Crop yields are moderate under a conservation management program. Crops respond well to applications of manure and complete commercial fertilizers mixed to meet the requirements of each crop. Supplemental irrigation during periods of moisture deficiencies, where fertilizers are used, will usually increase crop yields to near their potential.

| Mapping Unit | % Slope | ADP Code | Mapping Unit | % Slope | ADP Code | Mapping Unit | % Slope | ADP Code |
|---|---|---|---|---|---|---|---|---|
| Gilligan l | 0-3 | 33001 | Indianola l | 3-8 | 33001 | Wickersham shaly l | 0-3 | 33001 |
| Gilligan gl | 0-3 | " | Kickerville sil | 3-8 | " | Wickersham shaly l | 3-8 | " |
| Gilligan sil | 0-3 | " | Lynden l* | 0-3 | " | Wickersham shaly sil | 0-3 | " |
| Gilligan sil, shallow | 0-3 | " | Lynden l | 3-8 | " | | | |

Land Capability Unit IIIs06 (IIIs2) occurs on glacial outwash terraces with nearly level topography in a climatic zone having 15 to 20 inches of annual precipitation. It has a loamy fine sand surface, and a slightly acid (pH 6.1-6.5) loamy fine sand subsoil over a loose, loamy sand substratum.

The primary problem is soil management. The soil is suited for growing grasses, legumes, alfalfa, small grains, peas, potatoes, forage crops, strawberries, and cane fruits. The soil structure and soil productivity can be maintained by growing one or a combination of the following crops: grasses and legumes for 4 to 10 years followed by row crops 1 to 4 years, with winter cover crops between successive years of row crops; grasses and legumes 5 to 10 years, with 1 or 2 years of small grain; grasses and legumes 3 to 4 years, with strawberries 3 to 4 years; or grasses and legumes 5 to 10 years, with cane fruits and winter cover crops 7 to 10 years. Crop yields are moderate under a conservation management program. This soil responds well to sprinkler irrigation, and supplemental irrigation during periods of moisture deficiencies, where fertilizers are used, will usually increase crop yields to near their potential.

| Mapping Unit | % Slope | ADP Code |
|---|---|---|
| Dick lfs | 3-8 | 33006 |

Land Capability Unit IIIs08 (IIIs3) consists of deep, and well to moderately well drained soils with surfaces and subsoils of medium to strongly acid loams and silt loams. Their substrata consist of medium acid silt loams, silty clay loams, and fine sandy loams.

Management problems are maintenance of soil productivity, and wetness. The soils are well suited for growing strawberries, cane berries, vegetables, row crops, bulbs, small grains, forage, alfalfa, grasses and legumes for hay and pasture, and wood crops. They are suited for continuous cropping when winter cover crops, green manures, all available barnyard manure, and complete commercial fertilizers are used. Also, they are suited for growing hay and pasture 3 to 4 years; strawberries 3 to 4 years; hay and pasture 5 to 10 years, with row crops, vegetables, or bulbs 1 to 2 years; or cane fruits with annual cover crops 7 to 10 years. Crop yields are moderate to high under an intensive conservation management program. The wood crop productive potential is moderate to high. Lime applications may be beneficial to establishment and maintenance of legumes and legume-grass mixtures. Supplemental irrigation during periods of moisture deficiencies, where fertilizers are used, will usually increase crop yields to near their potential.

| Mapping Unit | % Slope | ADP Code | Mapping Unit | % Slope | ADP Code | Mapping Unit | % Slope | ADP Code |
|---|---|---|---|---|---|---|---|---|
| Giles l* | 0-3 | 33008 | Giles fsl | 0-3 | 33008 | Sauk l | 0-3 | 33008 |
| Giles sil (g subsoil) | 3-8 | " | Salal fsl | 0-3 | " | Winston gsl | 0-3 | " |

Land Capability Unit IIIsw09 (IIIs4) consists of moderately well drained, moderately deep glacial terraces on nearly level to undulating topography, with 0 to 8 percent slopes. The soils consist of loam, gravelly loam, and gravelly sandy loam, and the subsoils consist of moderately to strongly acid gravelly sandy loam, silty clay loam, or silty clay. The substrata are gravelly sandy loam, silty clay, sandy clay, or sandy clay loam cemented glacial till.

Management problems are maintenance of soil productivity, and wetness. Wetness is caused by flooding due to ponding during periods of excess precipitation. The soils are well suited for growing grasses, legumes, small grains, strawberries, cane fruits, and wood crops. Crop yields under a conservation management program are moderate to high. The land can be maintained against deterioration of soil and production can be maintained by growing grasses and legumes 4 to 10 years followed by 1 to 4 years of row crops, with winter cover crops between successive years of row crops; grasses and legumes 3 to 4 years, with strawberries 3 to 4 years; grasses and legumes 5 to 10 years, with cane fruits and winter cover crops 7 to 10 years; or, grasses and legumes 4 to 10 years, followed by 1 to 2 years of small grains. Sprinkler irrigation is well suited to these soils, and supplemental irrigation during periods of moisture deficiencies, where fertilizers are used, will usually increase crop yields to near their potential.

| Mapping Unit | % Slope | ADP Code | Mapping Unit | % Slope | ADP Code | Mapping Unit | % Slope | ADP Code |
|---|---|---|---|---|---|---|---|---|
| Alderwood gl | 0-3 | 33209 | Roche gl* | 0-3 | 33209 | Waddell l | 3-8 | 33209 |
| Cloquallum l | 3-8 | " | Roche gl | 3-8 | " | Waddell gl | 3-8 | " |
| Roche l | 0-3 | " | Roche gsl | 3-8 | " | Waddell gl | 8-15 | " |

Land Capability Unit IVew03 (IVe1) consists of moderately deep (20-36 inches), moderately well drained, moderately coarse, medium and moderately fine textured soils on glacial terraces, in a climatic zone having 20 to 30 inches of precipitation annually.

The primary problem is erosion control, and the secondary problem is flooding by ponding. Generally, the ponding appears as seeped areas on slopes or in small depressions. The soils are well suited for growing grasses, legumes, small grains, alfalfa, cane fruits and grapes. The land can be protected against deterioration from erosion, and fertility and productivity can be maintained, by growing grasses and legumes 4 to 10 years, with 1 or 2 years of small grains; or grasses and legumes 5 to 10 years followed by cane fruits or grapes 7 to 10 years, with winter cover crops between rows. Crop yields are moderate under a conservation management program. The soils are well suited to sprinkler irrigation, and supplemental irrigation during periods of moisture deficiencies, where fertilizers are used, will usually increase crop yields to near their potential. The rotations indicated above are adequate to prevent sediment sources, to protect soils against erosion losses, and to protect water quality in the streams.

| Mapping Unit | % Slope | ADP Code | Mapping Unit | % Slope | ADP Code | Mapping Unit | % Slope | ADP Code |
|---|---|---|---|---|---|---|---|---|
| Clallam gsl | 3-8 | 41203 | Sinclair gfsl | 8-15 | 41203 | Swantown l | 8-15 | 41203 |
| Elwha l | 8-15 | " | Sinclair shotty l* | 8-15 | " | Whidbey gsl | 8-15 | " |
| Sinclair gl | 8-15 | " | Sinclair shotty cl | 3-8 | " | | | |

Land Capability Unit IVew12 (IVe2) consists of soils with loam, silt loam and silty clay loam surfaces, and silty clay loam subsoils, and their substrata consist of cobbly and gravelly clay, and silty clay dense basal till. The soils occur on rolling topography with slope gradients of 3 to 15 percent.

The primary management problem is control of erosion and sediment, and the secondary problem is wetness. These soils are well suited for growing grasses, legumes, small grains, and wood crops. Protection against soil deterioration can be accomplished by crop rotations which consist of growing grasses and legumes for hay and pasture 5 to 10 years, with oats or other small grains one year as a cleanup crop prior to reestablishing desired grasses and legumes. Yields are moderate to high under a conservation management program. Crops respond well to applications of manures and complete commercial fertilizers. Sprinkler irrigation is fairly well suited to these soils. Supplemental irrigation during periods of moisture deficiencies, where fertilizers are used, will usually increase crop yields to near their potential. The above rotation will prevent sources of sediment, and will help to maintain the desired water quality of the streams.

| Mapping Unit | % Slope | ADP Code | Mapping Unit | % Slope | ADP Code | Mapping Unit | % Slope | ADP Code |
|---|---|---|---|---|---|---|---|---|
| Bow cl | 8-15 | 41212 | Bow sicl | 8-15 | 41212 | McKenna l | 8-15 | 41212 |
| Bow gl | 3-8 | " | Bow sil | 3-8 | " | Stossel cl | 8-15 | " |
| Bow gl | 8-15 | " | Bow sil | 8-15 | " | Whatcom sil* | 8-15 | " |
| Bow l | 8-15 | " | Casey fsl | 8-15 | " | Whatcom sil-McKenna sil complex | 3-8 | " |
| Bow sicl | 3-8 | " | Casey l | 8-15 | " | | | |

Land Capability Unit IVew14 (IVe3) consists of moderately deep and imperfectly drained soils on old glacial terraces with rolling topography. Their slope gradients range between 3 and 15 percent. The surface soils are silt loams and silty clay loams, the subsoils are loams and silty clay loams, and the substrata are cemented basal till consisting of gravelly sandy loam, gravelly clay loam or gravelly clay.

Stabilization of soils against erosion is the primary management problem, and wetness is secondary. The soil erosion and sediment hazards can be reduced and soil tilth, moisture-holding capacity, and crop yields can be improved by growing grasses and legumes for hay and pasture 5 to 10 years, with small grains 1 year as a cleanup crop, prior to reestablishing desired grasses and legumes. Crop yields are moderate under a good conservation management program. Crops respond well to applications of available manures and complete commercial fertilizers. Sprinkler irrigation is fairly suitable for these soils, considering their moderate water intake rates and water-holding capacities in the usable soil profile. Crops respond well to irrigation during periods of moisture deficiencies, and where fertilizers are used, crop yields may approach their potential. Crop rotations indicated above are adequate to control erosion and to reduce stream sediments and pollution.

| Mapping Unit | % Slope | ADP Code | Mapping Unit | % Slope | ADP Code | Mapping Unit | % Slope | ADP Code |
|---|---|---|---|---|---|---|---|---|
| Cloquallum sil | 8-15 | 41214 | Kitsap sil | 8-15 | 41214 | Squalicum gsil | 8-15 | 41214 |
| Cloquallum sil, shallow | 8-15 | " | Kitsap sicl* | 8-15 | " | Squalicum sil | 8-15 | " |
| | | | Labounty sil | 8-15 | " | Squalicum stsil | 8-15 | " |
| Cloquallum sicl | 8-15 | " | Quilcene sicl | 8-15 | " | Wilkeson l | 8-15 | " |
| Kitsap gl | 8-15 | " | Squalicum-Alderwood sil | 8-15 | " | Wilkeson sil | 8-15 | " |
| Kitsap sil-Indianola sl complex | 8-15 | " | | | | Prather sicl | 8-15 | " |
| | | | Squalicum gsil | 3-8 | " | | | |

Land Capability Unit IVew22 (IVe4) consists of moderately deep and deep, moderately well and imperfectly drained, glacial terrace soils, overlying cemented glacial basal till. The soils occur on slopes ranging between 3 and 15 percent. Their surfaces consist of medium and coarse textures which are silt loam, loam, gravelly loam, fine sandy loam and gravelly sandy loam. Their subsoils consist of coarse, moderately coarse, and moderately fine textures which are gravelly sand, gravelly sandy loam, sand, and gravelly clay loam.

Stabilization of soils against erosion is the primary problem, and wetness is the secondary problem. The soils are well suited for growing grasses, legumes, small grains, and wood crops. The soil erosion and sediment hazard can be reduced, and soil tilth, moisture-holding capacity, and crop yields can be improved by growing grasses and legumes for hay and pasture 5 to 10 years, with small grains for 1 year as a cleanup crop, prior to reestablishing desired grasses and legumes. Crop yields are moderate under a good conservation management program. Crops respond well to applications of available manures and complete commercial fertilizers. Sprinkler irrigation is fairly well suited for soils of this group during periods of moisture deficiencies. Crops respond well to supplemental irrigation, and with fertilizers, yields may approach their potential.

| Mapping Unit | % Slope | ADP Code | Mapping Unit | % Slope | ADP Code | Mapping Unit | % Slope | ADP Code |
|---|---|---|---|---|---|---|---|---|
| Alderwood fsl | 3-8 | 41222 | Alderwood gsl shallow | 3-8 | 41222 | Roche gl | 8-15 | 41222 |
| Alderwood fsl | 8-15 | " | Alderwood gsl shallow | 8-15 | " | Roche l | 8-15 | " |
| Alderwood gl | 3-8 | " | Bozarth fsl | 8-15 | " | Roche stl | 8-15 | " |
| Alderwood gl | 8-15 | " | Cagey gsl | 8-15 | " | Tenino gsl | 8-15 | " |
| Alderwood gsl* | 3-8 | " | Cagey sil | 8-15 | " | | | |
| Alderwood gsl | 8-15 | " | Kapowsin gl | 8-15 | " | | | |

Land Capability Unit IVes06 (IVe5) consists of moderately deep and deep, somewhat excessively drained, medium and coarse textured glacial outwash soils on slopes which range between 3 and 15 percent. The soils have silt loam, gravelly silt loam, and gravelly sandy loam surfaces. Their subsoils consist of gravelly sands and gravelly loams overlying gravelly sand substrata.

Stabilization of soils against erosion, and maintenance of soil structure, are the primary problems. The soils are well suited for growing grasses, legumes, small grains, and wood crops. They are best suited for growing grasses and legumes for hay and pasture 5 to 10 years, with small grains for 1 year as a cleanup crop prior to reestablishing the desired grasses and legumes. Crop yields are moderate to moderately low under a conservation management program. However, the crops respond well to applications of available manures and complete commercial fertilizers.

Land Capability Unit IVes06 (IVe5) (Con.)

Sprinkler irrigation is well suited to these soils, and supplemental irrigation during periods of moisture deficiencies, where fertilizers are used, will usually increase crop yields to near their potential.

| Mapping Unit | % Slope | ADP Code | Mapping Unit | % Slope | ADP Code | Mapping Unit | % Slope | ADP Code |
|---|---|---|---|---|---|---|---|---|
| Barneston sil | 8-15 | 41306 | Barnhardt gsil | 8-15 | 41306 | Corkindale l | 8-15 | 41306 |
| Barnhardt gsl | 8-15 | " | Corkindale l | 3-8 | " | Kickerville sil* | 8-15 | " |

Land Capability Unit IVes07 (IVe6) consists of moderately deep, well drained, gravelly, moderately coarse textured soils on low terraces with slopes which range between 3 and 15 percent. Their surfaces consist of loams and gravelly loams. Their subsoils are strongly acid, firm, gravelly, and very gravelly loams, which overlie very gravelly, cobbly and bouldery loams and sands.

Stabilization of soils against erosion and maintenance of soil structure are the primary management problems. The soils are well suited for growing grasses, legumes, small grains, and wood crops. They are well suited for growing grasses and legumes for hay and pasture 5 to 10 years, with small grains for 1 year as a cleanup crop, prior to reestablishing grasses and legumes. Crop yields are moderate to moderately low under a conservation management program. The soils are fairly well suited for sprinkler irrigation during periods of moisture deficiencies, and supplemental irrigation, where fertilizers are used, will usually increase crop yields to near their potential.

| Mapping Unit | % Slope | ADP Code | Mapping Unit | % Slope | ADP Code | Mapping Unit | % Slope | ADP Code |
|---|---|---|---|---|---|---|---|---|
| Nesika l soils, undifferentiated | 3-8 | 41307 | Sol Duc gl* | 8-15 | 41307 | | | |

Land Capability Unit IVes08 (IVe7) consists of moderately deep and shallow, moderately well drained, moderately coarse, and medium textured glacial terrace soils overlying dense, cemented glacial till. Slopes range between 3 and 15 percent. Their surfaces consist of gravelly sandy loam and gravelly loam which have an acidity ranging between pH 5.1 and 6.0. Their subsoils consist of gravelly sandy loam and gravelly loam overlying dense cemented gravelly sandy loam glacial basal till.

Management problems are the control of erosion and sedimentation, and maintenance of soil structure and productivity. While most of these soils are used for the production of wood crops, and watershed protection for reservoirs, they are suited for growing grasses, legumes, small grains, and wood crops. Where used for agriculture, the soils can be protected against erosion and deterioration by growing grasses and legumes for 5 to 10 years, with small grains for 1 year, prior to reestablishing the desired grasses and legumes. Shallow soils with limited water-holding capacities cause severe limitations for sprinkler irrigation.

| Mapping Unit | % Slope | ADP Code | Mapping Unit | % Slope | ADP Code | Mapping Unit | % Slope | ADP Code |
|---|---|---|---|---|---|---|---|---|
| Skiyou gl* | 3-8 | 41308 | Skiyou gl | 8-15 | 41308 | Tokul gsl | 8-15 | 41308 |

Land Capability Unit IVes09 (IVe8) consists of moderately deep, moderately fine textured soils overlying cemented glacial till and compact sands or bedrock at 40 to 48 inches. They occur on old upland terraces, with slopes ranging between 8 and 15 percent. Their surfaces consist of medium to strongly acid loam, gravelly loam, silt loam, and fine sandy loam. Their subsoils consist of loam, silty clay loam, and gravelly sandy loam over compact to strongly cemented sandy loam, gravelly sandy loam, or fine sandy loam.

Management problems are erosion and sedimentation hazards, and maintenance of soil structure and productivity. The soils are well suited for growing grasses, legumes, small grains, and wood crops. Conservation measures necessary to protect the soil against erosion and sediment hazards include growing grasses and legumes for hay and pasture 5 to 10 years, with oats used as a cleanup crop prior to reestablishing desired grasses and legumes. The soils are well suited for sprinkler irrigation, and supplemental irrigation during periods of moisture deficiencies, where fertilizers are used, will usually increase crop yields to near their potential.

| Mapping Unit | % Slope | ADP Code | Mapping Unit | % Slope | ADP Code | Mapping Unit | % Slope | ADP Code |
|---|---|---|---|---|---|---|---|---|
| Cathcart gl | 3-8 | 41309 | Giles l | 8-15 | 41309 | Saxon sil | 8-15 | 41309 |
| Cathcart gl | 8-15 | " | Giles sil | 8-15 | " | Shelton gl | 8-15 | " |
| Cathcart l | 8-15 | " | Nordby l | 3-8 | " | Shelton gsl* | 8-15 | " |
| Giles fsl | 8-15 | " | Nordby l | 8-15 | " | | | |

Land Capability Units IVes10, 11 (IVe9) consist of moderately shallow, moderately well and well drained, medium and moderately coarse textured glacial terrace soils on 3 to 15 percent slopes, in a climatic zone having 18 to 22 inches of precipitation annually. Their surfaces are sandy loam or gravelly sandy loam. Their subsoils consist of gravelly loam, gravelly sandy loam, or sandy loam, overlying cemented basal till of gravelly clay loam and gravelly sandy loam.

Management problems include the control of erosion and reduction of sediment, and maintenance of soil structure and productivity. These soils are suited for growing grasses, legumes, small grains, and wood crops. The conservation measures required to prevent soil erosion and soil deterioration include growing grasses and legumes 5 to 10 years, with small grains 1 to 2 years to establish seedings. Woodland use adequately protects the land against accelerated soil erosion, except for areas which have been recently logged. The soils are well suited for irrigation, and supplemental irrigation during periods of moisture deficiencies, where fertilizers are used, will usually increase crop yields to near their potential.

| Mapping Unit | % Slope | ADP Code | Mapping Unit | % Slope | ADP Code | Mapping Unit | % Slope | ADP Code |
|---|---|---|---|---|---|---|---|---|
| San Juan, gsl, moderately deep | 8-15 | 41311 | Townsend fsl | 3-8 | 41310 | Townsend sl* | 8-15 | 41310 |

Land Capability Units IVes13, 16 (IVe10) consist of moderately deep, well, and moderately well drained soils overlying basalt, sandstone or schist bedrock at 24 to 60 inches. Their slopes range between 8 and 15 percent. Their surface textures consist of loam and silty clay loam, and their subsoils consist of loam, shaly loam, clay loam and silty clay loam overlying bedrock.

Management problems are erosion and sediment control, and maintenance of soil structure and productivity. The soils are suited for growing grasses, legumes, small grains, and wood crops. Adequate protection against accelerated soil erosion and sediment hazards, and maintenance of soil structure, may be accomplished by growing grasses and legumes 5 to 10 years, followed by small grains 1 year, to reestablish the cover. Supplemental irrigation during periods of moisture deficiencies, where fertilizers are used, increases crop yields to near their potential.

| Mapping Unit | % Slope | ADP Code | Mapping Unit | % Slope | ADP Code | Mapping Unit | % Slope | ADP Code |
|---|---|---|---|---|---|---|---|---|
| Heisler shaly l* | 8-15 | 41313 | Melbourne sicl* | 8-15 | 41316 | Schnorbush l | 8-15 | 41313 |
| Melbourne l | 8-15 | 41316 | Olympic sicl | 8-15 | " | Tebo l | 8-15 | 41316 |

Land Capability Units IVws01, 02, 03 (IVw1) consist of deep, coarse, and moderately coarse textured alluvial soils. Their surfaces are loamy sandy and sandy loams which overlie sands and gravelly sands. The flood hazard is severe.

Management problems are wetness, and maintenance of soil productivity. This conservation management group of soils is best suited for growing grasses and legumes for hay and pasture, or trees for wood crops. Conservation measures suited for protecting these soils consist of growing grasses and legumes 5 to 10 years, with peas or silage corn 1 to 2 years to reestablish grass and legume cover. The soils are well suited for growing cottonwood for wood crops. They have low water-holding capacities and require frequent irrigation; however, during periods of moisture deficiencies, irrigation increases crop yields to near their potential.

| Mapping Unit | % Slope | ADP Code | Mapping Unit | % Slope | ADP Code | Mapping Unit | % Slope | ADP Code |
|---|---|---|---|---|---|---|---|---|
| Kline sl | 0-3 | 42302 | Pilchuck fsl* | 0-3 | 42301 | Sultan ls | 0-3 | 42303 |
| Newberg sl | 0-3 | " | Puyallup lfs | 0-3 | 42302 | | | |

Land Capability Unit IVws05 (IVw2) consists of deep, poorly drained soils with clay or silty clay surfaces and clay subsoils and substrata. These circumstances contribute to continuing wetness following floodwater recession.

Management problems are wetness, and maintenance of soil productivity. The soils are best suited for growing grasses and legumes for pasture, and cane berries. Conservation measures required to maintain these soils in a moderate to high state of productivity include growing hay and pasture 5 to 10 years, followed by cane berries 7 to 10 years. The soils have severe limitations for irrigation; however, supplemental irrigation during periods of moisture deficiencies, where fertilizers are used, may increase crop yields to near their potential.

| Mapping Unit | % Slope | ADP Code | Mapping Unit | % Slope | ADP Code | Mapping Unit | % Slope | ADP Code |
|---|---|---|---|---|---|---|---|---|
| Puget c* | 0-3 | 42305 | Puget sic | 0-3 | 42305 | Puyallup-Puget ls | 0-3 | 42305 |

Land Capability Unit IVws06 (IVw3) consists of shallow (12 to 20 inches deep), very poorly drained organic soils made up of peats and mucks overlying silts, sands, clays, and gravelly materials. Their quality after shrinkage to the mineral soil material depends upon the nature of the underlying subsoil. These organic soils will settle or shrink at the rate of about one inch per year.

Management problems are wetness, and maintenance of soil productivity. The soils are best suited for growing grasses and legumes for hay and pasture. However, until such time as soil settling has reduced the thickness of the organic layer to about 12 inches, the soils are suited for growing vegetables and blueberries.

| Mapping Unit | % Slope | ADP Code | Mapping Unit | % Slope | ADP Code | Mapping Unit | % Slope | ADP Code |
|---|---|---|---|---|---|---|---|---|
| Carbondale muck, shallow | 0-3 | 42306 | Rifle peat, shallow | 0-3 | 42306 | Spalding peat, burned phase | 0-3 | 42306 |
| Carbondale muck | 3-8 | " | Rifle peat-Bellingham sicl complex | 3-8 | " | Tacoma peat | 0-3 | " |
| Dupont muck | 0-3 | " | Semiahmoo muck, shallow* | 0-3 | " | Tacoma muck, shallow | 0-3 | " |
| McMurray muck | 0-3 | " | Semiahmoo-Tanwax muck/peat | 0-3 | " | Tanwax peat | 0-3 | " |
| McMurray peat, shallow | 0-3 | " | | | | Tanwax peat, shallow | 0-3 | " |
| Mukilteo peat | 8-15 | | | | | | | |
| Mukilteo peat, shallow | 0-3 | | | | | | | |

Land Capability Units IVws07, 08 (IVw4) consist of moderately shallow, poorly drained basin soils, with iron cemented subsoils and cemented or dense clay substrata. The soils occur on upland and terrace basins with slopes of less than 3 percent. Their surfaces consist of loams, gravelly loams, silt loams, gravelly sandy loams and loamy sands. Their subsoils consist of iron cemented sands overlying cemented sand or glacial clay till. They are subject to flooding due to ponding during periods of excess precipitation.

Management problems are wetness, and maintenance of soil fertility. Where drained, the soils are suited for growing grasses, legumes, and small grains. Where undrained, they are suited for growing Reed canarygrass and similar wetland grasses. The soil structure and productivity can be maintained by growing grasses and legumes 5 to 10 years, with 1 year of small grains to reestablish the grass and legumes. The soils are only fairly well suited for supplemental irrigation during periods of moisture deficiencies. Irrigation, along with the use of fertilizers, may increase crop yields to near their potential.

| Mapping Unit | % Slope | ADP Code | Mapping Unit | % Slope | ADP Code | Mapping Unit | % Slope | ADP Code |
|---|---|---|---|---|---|---|---|---|
| Edmonds ls | 0-3 | 42308 | Koch gsl | 0-3 | 42308 | Schooley l | 0-3 | 42307 |
| Koch gl | 0-3 | " | Koch sil* | 0-3 | " | | | |

Land Capability Units IVws09, 10 (IVw5) consist of poorly drained, moderately fine, and fine textured terrace and upland basin soils overlying restrictive layers at depths of 20 to 30 inches. The soils are subject to flooding by ponding during periods of excess precipitation.

Management problems are wetness, and maintenance of soil structure and productivity. The soils are suited for growing grasses, legumes, and small grains. They are fairly well suited to sprinkler irrigation, and supplemental irrigation during periods of moisture deficiencies, where fertilizers are used, may increase crop yields to near their potential.

| Mapping Unit | % Slope | ADP Code | Mapping Unit | % Slope | ADP Code | Mapping Unit | % Slope | ADP Code |
|---|---|---|---|---|---|---|---|---|
| Bellingham c | 0-3 | 42310 | Everson cl | 0-3 | 42309 | Reed c | 0-3 | 42310 |
| Bellingham sic* | 0-3 | " | McKenna gl* | 0-3 | " | Reed sicl | 0-3 | " |
| Bellingham sicl | 0-3 | " | McKenna gcl | 0-3 | " | Skagit sicl | 0-3 | " |
| Buckley cl | 0-3 | " | McKenna l | 0-3 | " | Thornton c | 0-3 | " |
| Buckley l | 0-3 | " | Orting stsl | 0-3 | " | Thornton sicl | 0-3 | " |

Land Capability Unit IVws11 (IVw6) consists of moderately shallow to shallow, poorly drained and imperfectly drained, medium, moderately fine, and fine textured upland terrace soils, on slopes of less than 8 percent. Their surfaces consist of loam, gravelly loam, silt loam, silty clay loam, and fine sandy loam, with an acidity of pH 5.1 to 6.0. Their subsoils consist of dense plastic clay, silty clay loam, or loam, and their substrata are dense plastic clay, silty clay, or silty clay loam. These soils are subject to flooding by ponding.

Management problems are wetness, and maintenance of soil structure and productivity. The soils are best suited for growing grasses, legumes, small grains, and wood crops. Conservation measures necessary to maintain these soils include grass and legume cover for 5 to 10 years, with small grains for 1 year to reestablish a grass and legume cover. Supplemental irrigation during periods of moisture deficiencies, where fertilizers are used, may increase crop yields to near their potential.

| Mapping Unit | % Slope | ADP Code | Mapping Unit | % Slope | ADP Code | Mapping Unit | % Slope | ADP Code |
|---|---|---|---|---|---|---|---|---|
| Bow l | 0-3 | 42311 | Bow gl* | 0-3 | 42311 | Casey l | 0-3 | 42311 |
| Bow l | 3-8 | " | Bow sil | 0-3 | " | Klaber sicl | 0-3 | " |
| Bow l, shallow | 0-3 | " | Bow sil, shallow | 0-3 | " | Kopiah l | 0-3 | " |
| Bow l-Bellingham sicl complex | 3-8 | " | Bow sil, shallow | 3-8 | " | Kopiah sicl | 0-3 | " |
| | | | Casey fsl | 0-3 | " | Kopiah sil | 0-3 | " |

Land Capability Units IVws12, 13 (IVw7) consist of moderately deep, moderately well drained, moderately fine textured soils overlying cemented glacial lacustrine substrata material. Their surfaces consist of silt loams and silty clay loams which have an acidity of pH 5.6 to 7.3. Their subsoils consist of plastic clay loams and silty clay loams which overlie sticky and plastic, densely cemented, silty clay loam and clay loam.

Management problems are wetness, and maintenance of soil structure and productivity. The soils can be stabilized and their productivity and soil structure maintained by following a rotation of growing hay and pasture 5 to 10 years, with small grains 1 year as a cleanup crop prior to reestablishing desired grasses and legumes. Crops grown upon these soils respond well to applications of barnyard manure and commercial fertilizers. Supplemental irrigation during periods of deficient moisture, where fertilizers are used, will usually increase crop yields to near their potential.

| Mapping Unit | % Slope | ADP Code | Mapping Unit | % Slope | ADP Code | Mapping Unit | % Slope | ADP Code |
|---|---|---|---|---|---|---|---|---|
| Agnew-Elwha sicl | 0-3 | 42313 | Cloquallum sil | 3-8 | 42312 | Kitsap sicl | 0-3 | 42312 |
| Agnew sicl* | 3-8 | " | | | | | | |

Land Capability Unit IVws43 (IVw8) consists of moderately deep, moderately well drained, moderately coarse textured soils on cemented glacial till terraces, with slopes which are generally less than 3 percent. Their surfaces consist of silt loam, loam, gravelly loam, gravelly sandy loam and fine sandy loam with an acidity of pH 5.1 to 6.0. Their subsoils consist of gravelly sandy loam overlying gravelly sandy loam cemented glacial till substrata. The soils are subject to seasonal water tables in their profiles, and ponding of low areas, during periods of excess precipitation.

Management problems are wetness, and maintenance of soil structure and productivity. Conservation measures required are crop rotation and land drainage. Land drainage can be accomplished by light land smoothing and tile drains to low wet areas. The soils are suited for growing grasses and legumes with rooting depths of less than 20 to 30 inches. They can be adequately protected against deterioration of productivity and structure by following a rotation of growing grasses and legumes 5 to 10 years, followed by 1 year of small grains to reestablish desired grasses and legumes. Crops respond well to irrigation during periods of deficient moisture, and, with applications of manure and complete commercial fertilizers, crop yields may approach their potential.

| Mapping Unit | % Slope | ADP Code | Mapping Unit | % Slope | ADP Code | Mapping Unit | % Slope | ADP Code |
|---|---|---|---|---|---|---|---|---|
| Alderwood gsl, shallow | 0-3 | 42343 | Bozarth fsl* | 0-3 | 42343 | Swantown l | 0-3 | 42343 |
| | | | Swantown gl | 3-8 | " | Whidbey gsl | 0-3 | " |

Land Capability Units IVs01, 10, 12 (IVs1) consist of somewhat excessively drained, moderately deep and deep, coarse and moderately coarse textured glacial outwash soils, on slopes of less than 15 percent gradient. Their surfaces consist of silt loam, loam, and fine sandy loam; some are gravelly. Their acidity ranges between pH 5.1 and 6.5. Their subsoils consist of gravelly sands and loamy sands.

Land Capability Units IVs01, 10, 12 (IVs1) (Con.)

The primary management problem is maintenance of soil structure and productivity. The soils are suited for growing grasses, legumes, small grains, potatoes, strawberries, cane fruits, and wood crops. Conservation measures required to maintain soil structure and productivity consist of growing grasses and legumes for hay and pasture 5 to 10 years, with 1 year of small grains as a cleanup crop prior to reestablishing desired grasses and legumes; grasses and legumes for hay and pasture 5 to 10 years, with oats for 1 year as a cleanup crop, and strawberries 3 to 4 years; grasses and legumes 5 to 10 years, with cane fruits 7 to 10 years and annual cover crops between rows of cane fruits; or grasses and legumes 5 to 10 years, small grains 1 year as a cleanup crop, and potatoes or vegetables 1 to 2 years. Supplemental irrigation during periods of moisture deficiencies, where fertilizers are used, may increase crop yields to near their potential.

| Mapping Unit | % Slope | ADP Code | Mapping Unit | % Slope | ADP Code | Mapping Unit | % Slope | ADP Code |
|---|---|---|---|---|---|---|---|---|
| Barneston gfsl | 0-3 | 43001 | Indianola fsl | 3-8 | 43001 | Snakelum cosl | 0-3 | 43010 |
| Barneston gfsl | 8-15 | " | Indianola sl | 0-3 | " | Snoqualmie gl | 3-8 | 43001 |
| Barneston gsl | 8-15 | " | Indianola sl | 3-8 | " | Sol Duc gl | 0-3 | " |
| Barneston sil | 3-8 | " | Indianola sil | 3-8 | " | Sol Duc gsl | 0-3 | " |
| Barnhardt gsl | 3-8 | " | Lynden gl | 0-3 | " | Spanaway gsl* | 0-3 | 43010 |
| Carlsborg gl | 0-3 | 43010 | Lynden gl | 3-8 | " | Spanaway gsl | 3-8 | " |
| Corkindale l | 0-3 | 43001 | Lynden gsl | 3-8 | " | Spanaway gsl | 8-15 | " |
| Crescent gl | 3-8 | " | Lynden sl* | 3-8 | " | Townsend l | 3-8 | " |
| Everett gl | 0-3 | " | National pumicy l | 3-8 | 43012 | Townsend gl | 3-8 | 43110 |
| Everett gl | 3-8 | " | National pumicy sl* | 3-8 | " | Townsend sl | 0-3 | 43010 |
| Everett gl | 8-15 | " | Neptune sl | 0-3 | 43001 | Tumwater fsl | 0-3 | " |
| Grove gl | 0-3 | " | Nisqually ls | 3-8 | 43010 | Tumwater lfs | 0-3 | " |
| Grove gl | 8-15 | " | Ragnar fsl | 3-8 | 43012 | | | |
| Grove gl, basin phase | 0-3 | " | Smith Creek gl | 3-8 | 43001 | | | |

Land Capability Units IVse05, 11, 13 (IVs2) consist of somewhat excessively drained, deep, coarse textured glacial outwash soils on slopes ranging between 8 and 15 percent gradient. Their surfaces consist of sandy loam, fine sandy loam, and loamy sand; some are gravelly. Their subsoils and substrata consist of loamy sand and sand. Their acidity ranges between pH 4.5 and 6.5.

Management problems are maintenance of soil productivity, and erosion and sediment control. The soils are suited for growing grasses, legumes, alfalfa, small grains, and wood crops. The conservation measures required to protect the soil against deterioration and erosion consist of growing grasses and legumes 5 to 10 years, with 1 year of small grains to reestablish the desired grasses and legumes. Supplemental irrigation during periods of moisture deficiencies, where fertilizers are used, may increase crop yields to near their potential.

| Mapping Unit | % Slope | ADP Code | Mapping Unit | % Slope | ADP Code | Mapping Unit | % Slope | ADP Code |
|---|---|---|---|---|---|---|---|---|
| Indianola fsl* | 8-15 | 43105 | Lynden gsl | 8-15 | 43105 | Ragnar fsl* | 8-15 | 43113 |
| Indianola lfs | 8-15 | " | Lynden sl | 8-15 | " | Snakelum cosl | 8-15 | 43111 |
| Indianola ls | 8-15 | " | Lystair fsl | 8-15 | " | Tumwater lfs | 8-15 | " |
| Indianola sl | 8-15 | " | Nisqually ls | 8-15 | 43111 | | | |

Land Capability Units IVsw06, 09 (IVs3) consist of moderately deep, moderately well drained, moderately coarse, and moderately fine textured glacial terrace soils overlying cemented glacial till substrata. Slopes range between 0 and 8 percent. Their surfaces consist of gravelly sandy loams, stony loams and gravelly silt loams with an acidity which ranges between pH 5.1 and 6.0. Their subsoils consist of gravelly sandy loam, fine sandy loam, and silty clay loam overlying cemented substrata.

Management problems are maintenance of soil productivity, and wetness. The soils are suited for growing grasses, legumes, small grains, cane fruits, and wood crops. Conservation measures necessary to protect the soil and maintain its productivity consist of growing grasses and legumes 4 to 10 years, with 1 year of small grains; or grasses and legumes 4 to 10 years, with cane fruits 7 to 10 years. Supplemental irrigation during periods of moisture deficiencies, where fertilizers are used, may increase crop yields to near their potential.

| Mapping Unit | % Slope | ADP Code | Mapping Unit | % Slope | ADP Code | Mapping Unit | % Slope | ADP Code |
|---|---|---|---|---|---|---|---|---|
| Alderwood gsl* | 0-3 | 43209 | Shelton gsl | 3-8 | 43209 | Whidbey gsl* | 3-8 | 43206 |
| Alderwood gsl | 3-8 | " | Sinclair gsl | 3-8 | 43206 | | | |
| Roche stl | 3-8 | " | Squalicum gsil | 0-3 | 43209 | | | |

Land Capability Units Vws21 and VIws02 (Vw1) consist of very poorly drained basin soils which occur behind ridges in coastal beach areas. These soils have a high water table that remains near the surface during most of the year. They lie within a few hundred feet of areas covered by tidal waves. As a result, the lower part of the profile is affected by salt water. The soil surface layers are dark in color, and overlie coarse textured sediments that extend to depths of many feet. The vegetation consists of sedges, reeds, and grasses that tolerate salt water. Most of the area is idle.

The primary management problem is the very wet condition of the soils which limits their use to growing vegetation that provides wildlife protection. The areas are best suited for the development of wildlife reserves. In some places, limited grazing is practiced during periods of below-normal precipitation. The soils are too wet and salty for other uses.

| Mapping Unit | % Slope | ADP Code | Mapping Unit | % Slope | ADP Code | Mapping Unit | % Slope | ADP Code |
|---|---|---|---|---|---|---|---|---|
| Alluvial complex | 0-3 | 52321 | Hovde l | 0-3 | 62302 | Hovde s | 0-3 | 62302 |
| Hovde gsl | 0-3 | " | Hovde ls | 0-3 | 52321 | Hovde sicl | 0-3 | 52321 |

Land Capability Units VIes18, 19, 22 and VIs19 (VIe1) consist of deep, somewhat excessively drained, moderately coarse and coarse textured, glacial outwash terrace soils on rolling and hilly topography, with slope gradients between 8 and 30 percent. The surface water runoff is medium to rapid, and the erosion hazard is severe.

Management problems are erosion, and soil droughtiness. Where cleared, the soils are suited for growing grasses, legumes, and wood crops. The land should be cultivated only to the extent necessary to establish or reestablish grass and legume cover. Erosion and droughtiness make the soils better suited for permanent vegetation or pasture, wood crops, wildlife, and recreational uses than for rotation cropland.

| Mapping Unit | % Slope | ADP Code | Mapping Unit | % Slope | ADP Code | Mapping Unit | % Slope | ADP Code |
|---|---|---|---|---|---|---|---|---|
| Barneston gfsl | 15-30 | 61319 | Fitch gsl | 8-15 | 63019 | Klaus gsl | 15-30 | 61322 |
| Barneston gls | 15-30 | " | Fitch gsl | 15-30 | 61319 | Klaus sl | 15-30 | " |
| Barneston gsl- | 15-30 | " | Grove cobbly sl | 15-30 | " | Lystair ls | 8-15 | 61319 |
| Wilkeson sil | | | Grove gsl | 15-30 | " | Lystair sl | 15-30 | " |
| complex | | | Grove vgsl | 15-30 | " | Lynden ls | 15-30 | " |
| Barneston sil | 15-30 | " | Hoypus cosl | 15-30 | 61322 | Lynden sl | 15-30 | " |
| Barneston stsil | 8-15 | " | Hoypus gls | 15-30 | " | Skykomish cobbly sl | 15-30 | " |
| Barnhardt gsil | 15-30 | " | Indianola fsl | 15-30 | 61319 | Skykomish gsl | 15-30 | " |
| Chimacum gl | 15-30 | 61322 | Indianola ls | 15-30 | " | Smith Creek gl | 15-30 | " |
| Chimacum gsl | 15-30 | " | Indianola sl | 15-30 | " | Thornwood gl | 8-15 | " |
| Chimacum vgls | 15-30 | " | Jolley vgl | 15-30 | " | Thornwood gl | 15-30 | " |
| Corkindale l | 15-30 | 61319 | Keystone ls | 15-30 | 61322 | Thornwood gsl | 15-30 | " |
| Everett gls | 15-30 | " | Kickerville sil | 15-30 | 61319 | Tumwater lfs | 15-30 | 61318 |
| Everett gsl | 15-30 | " | Klaus gl | 15-30 | 61322 | | | |

Land Capability Units VIew21, 23, 26 (VIe2) consist of moderately deep to shallow, moderately well drained, moderately coarse, medium, and moderately fine textured glacial terrace upland soils overlying cemented glacial till and bedrock. The soils occur on undulating and hilly topography, with slope gradients ranging from 3 to 30 percent. The surface water runoff is rapid, and the erosion hazard is moderate to severe.

Management problems are erosion, and wetness which is evident by seeps and wet basins. The soils are suited for growing grasses, legumes, and wood crops. Continuous grass, legume or woodland cover is necessary to adequately protect the soils against very severe erosion and sediment sources, to protect the water quality of the streams, and to stabilize the hydrology of the watersheds. The soils should be cultivated only to the extent necessary to reestablish grass, legume, or woodland cover. Generally, the soils are best suited for woodland, wildlife, and recreational purposes.

| Mapping Unit | % Slope | ADP Code | Mapping Unit | % Slope | ADP Code | Mapping Unit | % Slope | ADP Code |
|---|---|---|---|---|---|---|---|---|
| Agnew fsl | 15-30 | 61223 | Delphi gl | 15-30 | 61221 | Sinclair gfsl | 15-30 | 61226 |
| Agnew sl | 15-30 | " | Elwha l | 15-30 | 61223 | Sinclair gl | 15-30 | " |
| Agnew sicl | 15-30 | " | Hale sil | 15-30 | 61221 | Sinclair gsl | 15-30 | " |
| Alderwood fsl | 15-30 | 61221 | Heisler gl | 8-15 | " | Sinclair shotty l | 15-30 | " |
| Alderwood gl | 15-30 | " | Heisler gl | 15-30 | " | Skiyou gl | 15-30 | " |
| Alderwood gsl | 15-30 | " | Heisler shaly l | 15-30 | " | Squalicum-Alderwood | 15-30 | 61221 |
| Alderwood gsl, | 15-30 | " | Heisler stl | 15-30 | " | sil | | |
| shallow phase | | | Kapowsin gcl | 15-30 | " | Squalicum-Alderwood | 15-30 | " |
| Alderwood l | 15-30 | " | Kapowsin gl | 15-30 | " | stsil | | |
| Alderwood ls | 3-8 | " | Kapowsin gsl | 15-30 | " | Squalicum gsil | 15-30 | " |
| Alderwood ls | 15-30 | " | Kitsap gl | 15-30 | " | Squalicum sil | 15-30 | " |
| Alderwood stl | 3-8 | " | Kitsap sil | 15-30 | " | Squalicum stsil | 15-30 | " |
| Alderwood stl | 8-15 | " | Labounty-McKenna sil | 15-30 | " | Swantown gsl | 0-3 | 61226 |
| Alderwood stl | 15-30 | " | Oso l | 8-15 | " | Swantown gsl | 3-8 | " |
| Clallam gsl | 15-30 | 61223 | Oso l | 15-30 | " | Swantown gsl | 8-15 | " |
| Cloquallum sil | 15-30 | 61221 | Oso l | 3-8 | " | Whidbey gsl | 15-30 | " |
| Colvos fsl | 3-8 | " | Prather sicl | 15-30 | " | Wilkeson sil | 15-30 | 61221 |
| Colvos fsl | 15-30 | " | Quilcene sicl | 15-30 | " | Wilkeson l | 15-30 | " |
| Colvos fsl- | 3-8 | " | Roche gl | 15-30 | " | | | |
| Everett gsl | | | Roche stl | 15-30 | " | | | |
| Colvos fsl- | 15-30 | " | Roche stsl | 8-15 | " | | | |
| Everett gsl | | | Schnorbush-Norma sil | 8-15 | " | | | |

Land Capability Units VIes17, 20, 21, 23, 24, and VIs16 (VIe3) consist of moderately deep to shallow, moderately well drained, moderately coarse, medium, and moderately fine textured glacial terrace upland soils overlying cemented glacial till and bedrock. The soils occur on undulating and hilly topography, with slope gradients ranging from 3 to 30 percent. The surface water runoff is rapid, and the erosion hazard is moderate to severe.

Management problems are sedimentation, water quality, erosion, and maintenance of soil structure and productivity, with the exception of Hoodsport gravelly sandy loam, 0 to 3 percent slopes, which has a problem of soil maintenance only. The soils are suited for growing grasses, legumes, and wood crops. Continuous grass, legume, or woodland cover is necessary to adequately protect the soils against a very severe erosion hazard. The soils should be cultivated only to the extent necessary to reestablish grass and legume cover. While grasses and legumes are grown on these soils, they are better suited for wood crop production, wildlife and recreational purposes.

Land Capability Units VIes17, 20, 21, 23, 24, and VIs16 (VIe3) (Con.)

| Mapping Unit | % Slope | ADP Code | Mapping Unit | % Slope | ADP Code | Mapping Unit | % Slope | ADP Code |
|---|---|---|---|---|---|---|---|---|
| Cathcart gl | 15-30 | 61320 | Giles sil, g sub-soil phase | 15-30 | 61320 | Hoodsport vgsl | 8-15 | 61324 |
| Cathcart gsil | 15-30 | " | | | | Hoodsport vgsl | 15-30 | " |
| Cathcart l | 15-30 | " | Harstine gsl | 8-15 | " | San Juan stl | 15-30 | 61317 |
| Cathcart sil | 8-15 | " | Harstine gsl | 15-30 | " | Saxon sil | 15-30 | 61320 |
| Cathcart stl | 15-30 | " | Heisler gl | 3-8 | " | Schnorbush l | 15-30 | " |
| Clallam gl | 15-30 | 61323 | Hoodsport gsl | 0-3 | 63016 | Shelton gsl | 15-30 | 61324 |
| Dabob vgsl | 3-8 | 61320 | Hoodsport gsl | 8-15 | 61324 | Tenino gsl | 15-30 | 61321 |
| Dabob vgsl | 15-30 | " | Hoodsport gsl | 15-30 | " | Townsend sl | 15-30 | 61317 |
| Giles fsl | 15-30 | " | Hoodsport stsl | 8-15 | " | | | |
| Giles l | 15-30 | " | Hoodsport stsl | 15-30 | " | | | |

Land Capability Unit VIes25 (VIe4) consists of soils and land forms that are extremely variable in depth. They range from very shallow to deep, and overlie bedrock consisting of sandstone, basalt, and shale. Slopes of the area range between 3 and 30 percent. The surface water runoff is rapid, and the erosion hazard is moderate to severe.

Management problems are erosion, sedimentation, hydrology, maintenance of soil structure, and water intake. The soils are suited for growing grasses and legumes for hay and pasture, and wood crops. Generally, the lands are used for wood crop production. Where used for hay and pasture, they can be protected against erosion and deterioration by growing grasses and legumes until such time as the grasses and legumes require renovation or reseeding. However, they are best suited for wood crop production, wildlife, and recreational purposes.

| Mapping Unit | % Slope | ADP Code | Mapping Unit | % Slope | ADP Code | Mapping Unit | % Slope | ADP Code |
|---|---|---|---|---|---|---|---|---|
| Astoria sil | 8-15 | 61325 | Melbourne stl | 15-30 | 61325 | Rough mountainous land | 15-30 | 61325 |
| Astoria sil | 15-30 | " | Olympic sicl | 15-30 | " | | | |
| Marblemount stl | 15-30 | " | Olympic stcl | 8-15 | " | Tebo gl | 8-15 | " |
| Melbourne l | 0-3 | " | Olympic stcl | 15-30 | " | Tebo gl | 15-30 | " |
| Melbourne l | 3-8 | " | Pickett r outcrop complex | 15-30 | " | Tebo l | 15-30 | " |
| Melbourne sicl | 15-30 | " | | | | | | |
| Melbourne stl | 8-15 | " | | | | | | |

Land Capability Unit VIes27 (VIe5) consists of soils that are variable in depth, rocky, or very gravelly, with moderate to steep slopes between 8 and 30 percent. They have formed on conglomerate, granite or serpentine rocks in areas of high rainfall.

Management problems are erosion and sediment control, and maintenance of soil structure. The soils are suited for growing grasses and legumes for hay and pasture, and for wood crop production. Generally, the lands are best suited for wood crop production, wildlife and recreational uses, and watershed protection. Where used for hay and pasture, the soils can be protected against erosion and deterioration by maintaining them in grasses and legumes until such time as these crops require renovation or reseeding.

| Mapping Unit | % Slope | ADP Code | Mapping Unit | % Slope | ADP Code | Mapping Unit | % Slope | ADP Code |
|---|---|---|---|---|---|---|---|---|
| Discovery Bay gsl | 15-30 | 61327 | Fidalgo rl | 8-15 | 61327 | Roche-rock complex | 15-30 | 61327 |
| Discovery Bay gsl-r outcrop complex | 15-30 | " | Fidalgo rl | 15-30 | " | | | |
| | | | Olele vgsil | 15-30 | " | | | |

Land Capability Unit VIew28 (VIe6) consists of shallow and moderately deep (20 to 36 inches), poorly and imperfectly drained, moderately fine, and fine textured soils overlying dense glacial clay till. They occur on rolling to steep topography, with slope gradients ranging between 3 and 30 percent. The surface water runoff is rapid, and the erosion hazard is severe. Free water accumulates in the soil over the dense basal till, and may move laterally and surface as seep spots at lower elevations.

Management problems are erosion, sedimentation, and wetness. The soils are suited for growing grasses, legumes, and wood crops. Areas seeded to grasses and legumes should remain in this type of cover until such time as the seeding deteriorates and needs renovation. The soils should then be cultivated only to the extent necessary to reestablish the grass and legume cover. The soils are well suited for wood crop production, wildlife, and watershed protection.

| Mapping Unit | % Slope | ADP Code | Mapping Unit | % Slope | ADP Code | Mapping Unit | % Slope | ADP Code |
|---|---|---|---|---|---|---|---|---|
| Bow cl | 15-30 | 61228 | Bow sil | 15-30 | 61228 | Coveland stsil | 8-15 | 61228 |
| Bow gl | 15-30 | " | Bow stsil | 3-8 | " | Stossel stl | 15-30 | " |
| Bow gsil | 15-30 | " | Casey fsl | 15-30 | " | Whatcom sil | 15-30 | " |
| Bow l | 15-30 | " | Casey l | 15-30 | " | | | |

Land Capability Unit VIws19 (VIw1) consists of excessively drained, coarse textured alluvial soils, subject to frequent overbank flow flooding. Their surfaces consist of sands, loamy sands, fine sands, loamy fine sands, gravelly loamy sands, sandy loams and loams, with an acidity ranging from pH 5.1 to 6.5. Their subsoils are coarse textured sands, and they overlie sands, or gravelly and cobbly sands.

Management problems are wetness from overbank flow flooding and stabilization of soils against streambank erosion. The soils are suited for wildlife and recreational uses. However, the land is best suited for growing cottonwood, which is one of the most effective means of stabilizing the soils against streambank erosion and channeling. Areas protected by levees are suited for growing grasses and legumes for hay and pasture. Grasses and legumes should remain as a permanent cover on the land until such time as renovation is necessary.

Land Capability Unit VIws19 (VIw1) (Con.)

| Mapping Unit | % Slope | ADP Code | Mapping Unit | % Slope | ADP Code | Mapping Unit | % Slope | ADP Code |
|---|---|---|---|---|---|---|---|---|
| Edgewick s | 0-3 | 62319 | Newberg lfs | 0-3 | 62319 | Pilchuck lfs, shallow | 0-3 | 62319 |
| Juno gsl | 0-3 | " | Newberg ls | 0-3 | " | Pilchuck ls | 0-3 | " |
| Juno l | 0-3 | " | Pilchuck fs | 0-3 | " | Pilchuck sl | 0-3 | " |
| Juno ls | 0-3 | " | Pilchuck gls | 0-3 | " | | | |
| Juno sl | 0-3 | " | Pilchuck lfs | 0-3 | " | | | |

Land Capability Units VIs10, 12, 13, and VIse13 (VIs1) consist of deep, somewhat excessively drained, moderately coarse, and coarse textured glacial outwash soils on slope gradients generally of less than 8 percent. Their subsoils consist of sands and loamy sands; some have gravel, cobbles and stones mixed through the sands. The surface water runoff is slow, and the erosion hazard is slight.

The primary management problems are maintaining soil structure and water intake rates. Minor areas of soils on 8 to 15 percent slope have been included because the recommended management will control erosion and sediment on soils with rapid permeabilities. The soils are fairly well suited for growing grasses, legumes, and wood crops. Grasses and legumes should be permanent, with only sufficient cultivation to reseed desired grasses and legumes. Generally, under common-level management, the yields, where harvested for hay, range between 1.5 and 1.8 tons per acre. Low water-holding capacities seriously limit production of hay or other crops, and yields are low on these soils. Water requirements are high, and crop yields are too low to fully justify irrigation for top production under 1968 economic conditions. The soils are well suited for wildlife and recreational uses.

| Mapping Unit | % Slope | ADP Code | Mapping Unit | % Slope | ADP Code | Mapping Unit | % Slope | ADP Code |
|---|---|---|---|---|---|---|---|---|
| Carlsborg gsl | 0-3 | 63010 | Greenwater ls | 8-15 | 63113 | Klaus gl | 8-15 | 63113 |
| Chimacum gl | 3-8 | 63012 | Hoypus cosl | 0-3 | 63012 | Klaus gsl | 0-3 | 63012 |
| Chimacum gsl | 3-8 | " | Hoypus cosl | 8-15 | 63013 | Klaus gsl | 3-8 | " |
| Chimacum vgls | 8-15 | 63113 | Hoypus gls | 0-3 | 63012 | Klaus gsl | 8-15 | 63113 |
| Cispus pumicy sl | 0-3 | 63012 | Hoypus gls | 3-8 | " | Klaus sl | 0-3 | 63012 |
| Dick ls complex | 3-8 | " | Hoypus gls | 8-15 | 63013 | Klaus sl | 3-8 | " |
| Dick ls | 8-15 | 63113 | Keystone fsl | 0-3 | 63012 | Klaus sl | 8-15 | 63013 |
| Greenwater ls | 0-3 | 63012 | Keystone ls | 0-3 | " | Neptune gsl | 3-8 | 63010 |
| Greenwater ls | 3-8 | " | Keystone ls | 8-15 | 63113 | Pondilla fs | 0-3 | 63012 |
| Greenwater s | 3-8 | " | Klaus gl | 0-3 | 63012 | Ragnar fsl | 15-30 | 63113 |
| Greenwater sl | 0-3 | " | Klaus gl | 3-8 | " | | | |

Land Capability Units VIs01, 14, 18, and VIse15, 17 (VIs2) consist of moderately deep, excessively drained, gravelly soils in the high rainfall area (50 to 70 inches). Most slopes are less than 8 percent. Surface soils are sandy loams and loamy sands; some are gravelly. Subsoils are very gravelly sandy loams or loamy sands. The surface water runoff is slow, and the erosion hazard is slight, except on slopes of 8 to 15 percent, where it is moderate.

The primary management problems are maintaining soil structure and water intake rates. These soils are fairly well suited for growing grasses, legumes, and wood crops. Grasses and legumes should be permanent, with only sufficient cultivation to reseed desired grasses and legumes. Generally, under common-level management, the yields where harvested for hay range between 1.5 and 1.8 tons per acre. Low water-holding capacities seriously limit production of hay or other crops, and yields are low on these soils. Water requirements are high, and crop yields are too low to fully justify irrigation for top production under 1968 economic conditions. While rapidly permeable soils on 8 to 15 percent slopes are included here, the recommended management practices are adequate to protect the land against erosion and sedimentation. The soils are well suited for wildlife and recreational uses.

| Mapping Unit | % Slope | ADP Code | Mapping Unit | % Slope | ADP Code | Mapping Unit | % Slope | ADP Code |
|---|---|---|---|---|---|---|---|---|
| Barneston gls | 8-15 | 63117 | Grove stsl | 0-3 | 63014 | Skykomish cobbly sl | 0-3 | 63018 |
| Everett cobbly sl | 0-3 | 63018 | Grove vgsl | 3-8 | " | Skykomish cobbly sl | 3-8 | " |
| Everett gls | 0-3 | " | Indianola ls | 0-3 | 63018 | Skykomish cobbly sl | 8-15 | " |
| Everett gls | 3-8 | " | Indianola ls | 3-8 | " | Skykomish gl | 3-8 | " |
| Everett gls | 8-15 | " | Indianola sl-Roche l complex | 3-8 | " | Skykomish gsl | 3-8 | " |
| Everett gsl | 0-3 | " | | | | Skykomish gsl | 8-15 | " |
| Everett gsl | 3-8 | " | Indianola sl-Roche l complex | 8-15 | 63117 | Snoqualmie gls | 3-8 | 63001 |
| Everett gsl | 8-15 | 63117 | | | | Snoqualmie gsl | 3-8 | " |
| Fitch gsl | 0-3 | 63001 | Lynden ls | 0-3 | 63018 | Snoqualmie gsl, terrace phase | 3-8 | " |
| Fitch gsl | 3-8 | " | Lynden ls | 3-8 | " | | | |
| Grove cobbly sl | 0-3 | 63014 | Lynden ls | 8-15 | 63117 | Thornwood gl | 0-3 | 63018 |
| Grove cobbly sl | 8-15 | 63115 | Lynden sl | 0-3 | 63018 | Thornwood gl | 3-8 | " |
| Grove gsl | 0-3 | 63014 | Lystair ls | 3-8 | 63014 | Thornwood gsl | 0-3 | " |
| Grove gsl | 3-8 | " | Lystair sl | 3-8 | " | Thornwood gsl | 3-8 | " |
| Grove gsl | 8-15 | 63115 | Lystair sl | 8-15 | 63115 | Thornwood gsl | 8-15 | 63117 |

Land Capability Units VIs21 and VIse21 (VIs3) consist of moderately deep, moderately coarse or coarse textured, excessively drained soils formed in gravelly outwash or alluvium. Surface soils are dark colored sands, gravelly loams, or sandy or stony loams, relatively high in organic matter. Subsoils are very gravelly loams, sandy loams, or loamy sands with rapid permeabilities. Runoff is slow, and wind and water erosion hazards are slight.

The primary management problems are maintenance of soil structure and water intake rates. Slight erosion and sedimentation may be problems on hilly areas; however, the recommended conservation measures adequately protect soils against deterioration. The soils are fairly well suited for growing grasses, legumes, and wood crops. Grasses and legumes should be permanent, with only sufficient cultivation to reseed them. Generally, under common-level management, the yields, where harvested for hay, range between 1.5 and 1.8 tons per acre. Low water-holding capacities seriously limit the production of hay or other crops, and yields are low on these soils. Water requirements are high, and crop yields are too low to fully justify irrigation for top production under 1968 economic conditions. The soils are well suited for wildlife and recreational uses.

Land Capability Units VIs21 and VIse21 (VIs3) (Con.)

| Mapping Unit | % Slope | ADP Code | Mapping Unit | % Slope | ADP Code | Mapping Unit | % Slope | ADP Code |
|---|---|---|---|---|---|---|---|---|
| Carstairs gl | 0-3 | 63021 | San Juan gsl | 3-8 | 63021 | Spanaway gsl | 15-30 | 63121 |
| Nisqually s | 3-8 | " | San Juan gsl | 15-30 | 63121 | Spanaway stl | 0-3 | 63021 |
| San Juan cosl | 0-3 | " | San Juan stsl | 3-15 | " | Spanaway stl | 8-15 | " |
| San Juan cosl | 8-15 | " | San Juan stsl | 15-30 | " | | | |

Land Capability Units VIIew30, 33 (VIIe1) consist of well drained and moderately well drained, moderately deep, deep, and shallow soils overlying bedrock, cemented glacial till or dense lacustrine materials, all of which limit root and water penetration. The soils occur on steep slopes which generally exceed 30 percent gradient. Their surfaces consist of medium, moderately coarse, or moderately fine textured soils. Some have stony and rocky phases. Their subsoils consist mostly of medium and moderately fine textured materials or stony and rock phases which grade into the underlying substrata of cemented glacial till, dense lacustrine materials or bedrock at depths ranging from less than 1 foot to 5 feet or more. The surface water runoff is rapid, and the erosion hazard is severe.

Management problems are erosion and sedimentation, and wetness, which may occur as a seasonal water table, or as seep areas. The soils are best suited for growing Douglas-fir, western hemlock and red alder for wood products. They are too steep for other agricultural uses. They are well suited for wildlife and recreation. Woodland cover and careful management are necessary on steep and very steep slopes to prevent erosion and sedimentation, and to maintain water quality.

| Mapping Unit | % Slope | ADP Code | Mapping Unit | % Slope | ADP Code | Mapping Unit | % Slope | ADP Code |
|---|---|---|---|---|---|---|---|---|
| Alderwood gl | 30-45 | 71230 | Discovery Bay vgsl | 15-30 | 71230 | Oso l | 30-45 | 71230 |
| Alderwood gsl | 30-45 | " | Discovery Bay-rock outcrop complex | 30-45 | " | Prather sicl | 30-45 | 71233 |
| Colvos fsl | 30-45 | " | | | | Quilcene sicl | 30-45 | 71230 |
| Colvos-rock outcrop complex | 30-45 | " | Jolley vgl | 30-45 | " | Squalicum gsil | 30-45 | " |
| | | | Kitsap sil | 30-45 | " | Squalicum sil | 30-45 | " |

Land Capability Units VIIes30, 34 (VIIe2) consist of well drained and moderately well drained, moderately deep, deep, and shallow soils overlying bedrock, cemented glacial till, or dense lacustrine materials, all of which limit root and water penetration. The soils occur on steep slopes which generally exceed 30 percent gradient. Their surfaces consist of medium, moderately coarse, or moderately fine textured soils. Some have stony and rocky phases. Their subsoils consist mostly of medium and moderately fine textured materials or stony and rock phases which grade into the underlying substrata of cemented glacial till, dense lacustrine materials or bedrock at depths ranging from less than 1 foot to 5 feet or more. The surface water runoff is rapid, and the erosion hazard is severe.

Management problems are erosion and sediment control, and maintenance of soil structure and water intake rates. The land is too steep for agricultural uses, other than for growing Douglas-fir, western hemlock and red alder for wood products. The soils are suited for wildlife, recreational and watershed protection purposes.

| Mapping Unit | % Slope | ADP Code | Mapping Unit | % Slope | ADP Code | Mapping Unit | % Slope | ADP Code |
|---|---|---|---|---|---|---|---|---|
| Discovery Bay gsl | 30-45 | 71330 | Hoypus gls | 30-45 | 71334 | Skiyou gl | 30-45 | 71334 |
| Discovery Bay vgsl | 30-45 | " | Sinclair gsl | 30-45 | " | | | |

Land Capability Units VIIew31, 32 (VIIe3) consist of moderately deep and deep, well and moderately well drained soils, on upland marine terraces and glacial till with slopes over 30 percent. The surface soils are medium to moderately fine textured, and the subsoils are compact, fine and medium textured materials. The runoff is rapid, and the erosion hazard is severe.

Management problems are control of erosion and sedimentation, and wetness, which occurs as excess water in the soil profiles overlying restrictive layers. The soils are best suited for growing Douglas-fir, western hemlock and red alder for wood products. Except for woodlands, wildlife, recreation, and watershed protection, the soils are too steep for agricultural uses.

| Mapping Unit | % Slope | ADP Code | Mapping Unit | % Slope | ADP Code | Mapping Unit | % Slope | ADP Code |
|---|---|---|---|---|---|---|---|---|
| Agnew sicl | 30-45 | 71232 | Bow sil | 30-45 | 71231 | Whatcom sil | 30-45 | 71231 |
| Bow gl | 30-45 | 71231 | Clallam l | 30-45 | 71232 | | | |

Land Capability Unit VIIes33 (VIIe4) consists of deep, well drained, moderately fine and medium textured soils on steep slopes over 30 percent. The subsoils are moderately fine textured; some are gravelly. The runoff is rapid, and the erosion hazard is severe.

Management problems are erosion and sediment control, and maintenance of soil structure and water intake rates. These soils are best suited for growing Douglas-fir, western hemlock and red alder for wood products, and for wildlife, recreation, and watershed protection uses.

| Mapping Unit | % Slope | ADP Code | Mapping Unit | % Slope | ADP Code | Mapping Unit | % Slope | ADP Code |
|---|---|---|---|---|---|---|---|---|
| Melbourne sicl | 30-45 | 71333 | Olympic sicl | 30-45 | 71333 | Tebo gl | 30-45 | 71333 |

Land Capability Unit VIIes35 (VIIe5) consists of shallow to moderately deep, very gravelly, stony or rocky soils formed in residual material or glacial till in areas of high rainfall (45 to 70 inches). Slopes are usually more than 30 percent, but some 8 to 15 percent areas are included. The runoff is medium to rapid, and the erosion hazard is slight to severe.

Management problems are erosion and sediment control, and maintenance of soil structure and water intake rates. The soils are best suited for growing Douglas-fir, western hemlock and red alder for wood products, and they are also well suited for wildlife, recreational, and watershed protection purposes.

| Mapping Unit | % Slope | ADP Code | Mapping Unit | % Slope | ADP Code | Mapping Unit | % Slope | ADP Code |
|---|---|---|---|---|---|---|---|---|
| Ahl sil complex | 30-45 | 71335 | Cathcart stl | 30-45 | 71335 | Olele vgsil | 8-15 | 71335 |
| Ahl vgsil | 30-45 | " | Fidalgo rl | 30-45 | " | Olele vgsil | 30-45 | " |
| Cathcart gl | 30-45 | " | Heisler stl | 30-45 | " | Pickett rsil | 30-45 | " |
| Cathcart gsil | 30-45 | " | Hoodsport gsl | 30-45 | " | Shelton gsl | 30-45 | " |
| Cathcart l | 30-45 | " | Kickerville sil | 30-45 | " | | | |

Land Capability Unit VIIes29 (VIIe6) consists of deep, somewhat excessively drained, moderately coarse and coarse textured glacial outwash terrace soils on steep topography, with slope gradients ranging between 8 and 50 percent. Their surfaces consist of coarse, moderately coarse, gravelly, very gravelly, cobbly and stony textures, with acidity ranging between pH 5.1 and 6.0. Their subsoils and substrata consist of sands and gravelly, very gravelly, cobbly, stony sands. The surface water runoff is medium to rapid, and the erosion hazard is severe to very severe.

Management problems are erosion and sedimentation control, and maintenance of soil structure to protect the water intake rates. The soils are best suited for growing Douglas-fir for wood crops. They are also well suited for wildlife, recreational, and watershed protection purposes.

| Mapping Unit | % Slope | ADP Code | Mapping Unit | % Slope | ADP Code | Mapping Unit | % Slope | ADP Code |
|---|---|---|---|---|---|---|---|---|
| Barnhardt gsl | 30-45 | 71329 | Everett stsl | 8-15 | 71329 | Grove vgsl | 30-45 | 71329 |
| Corkindale l | 30-45 | " | Everett stsl | 15-30 | " | Indianola ls | 30-45 | " |
| Everett gsl | 30-45 | " | Everett stsl | 30-45 | " | Keystone ls | 30-45 | " |
| Everett stls | 8-15 | " | Grove gsl | 30-45 | " | Thornwood gsl | 30-45 | " |

Land Capability Unit VIIes36 (VIIe7) consists of rough broken or stony and mountainous lands, and rock lands. The soils have variable depths and textures. They are usually shallow, but some deep areas occur. Slopes generally are over 30 percent, and many are 65 percent and more. The runoff is rapid, and the erosion hazard is slight to severe.

These are miscellaneous land types. Some timber is grown, but the soils are used mainly for wildlife and water yield areas.

| Mapping Unit | % Slope | ADP Code | Mapping Unit | % Slope | ADP Code | Mapping Unit | % Slope | ADP Code |
|---|---|---|---|---|---|---|---|---|
| Ahl r complex | 30-45 | 71336 | Rough broken land, schist bedrock | 30-45 | 71336 | Rough broken land, st to extremely r | 15-30 | 71336 |
| Roche-rock rl complex | 30-45 | " | Rough broken land, st | 30-45 | " | Rough broken rocky | 30-45 | " |
| Rock lands | 30-45 | " | Rough broken land, st complex | 30-45 | " | Rough stony land | 30-45 | " |
| Rock lands, r | 8-15 | " | Rough broken land, st to cobbly | 30-45 | " | Steep broken land | 30-45 | " |
| Rough broken land | 30-45 | " | Rough broken land, st to extremely r | 30-45 | " | | | |
| Rough broken land complex | 30-45 | " | | | | | | |
| Rough broken land, r to extremely r | 30-45 | " | | | | | | |

Land Capability Unit VIws20 (VIw1) consists of deep, excessively drained, coarse textured, bottom land soils. Their surfaces consist of sands and gravelly sands, and their subsoils and substrata are sands, gravels, and cobbles. They have very severe limitations, due to frequent overflow and very low water-holding capacity of the coarse textures. The surface water runoff is slow.

Management problems are wetness due to streambank overflow flooding, and maintenance of soils against streambank cutting and sedimentation. The soils are best suited for growing cottonwood, which protects them against streambank erosion and channeling. They are also well suited for limited wood crop production, wildlife, and recreational uses.

| Mapping Unit | % Slope | ADP Code | Mapping Unit | % Slope | ADP Code | Mapping Unit | % Slope | ADP Code |
|---|---|---|---|---|---|---|---|---|
| Pilchuck gs | 0-3 | 72320 | Pilchuck s | 0-3 | 72320 | | | |

Land Capability Unit VIIs23 (VIIs1) consists of somewhat excessively drained, moderately deep, and deep, coarse textured, glacial outwash soils on slopes of less than 8 percent gradient. Their surfaces consist of stony sandy loams and stony sands, with an acidity range between pH 5.6 and 6. Their subsoils and substrata consist of loose, stony, gravelly sands. The surface water runoff is slow, and the erosion hazard is slight.

The primary management problem is the protection of soil structure and water intake rates. The soils are best suited for growing Douglas-fir for wood crops. They are also well suited for recreation, wildlife, and watershed protection uses.

| Mapping Unit | % Slope | ADP Code | Mapping Unit | % Slope | ADP Code | Mapping Unit | % Slope | ADP Code |
|---|---|---|---|---|---|---|---|---|
| Everett stsl | 0-3 | 73023 | Skykomish stl | 3-8 | 73023 | Skykomish sts | 3-8 | 73023 |
| Skykomish gs | 3-8 | " | | | | | | |

Land Capability Unit VIIes37 (VIIIe1) consists of miscellaneous land types that, because of extreme erosion limitations, are suited only for growth of vegetation to provide watershed protection, and for wildlife use. The soils are very shallow, stony and rocky. Soil materials are extremely unstable, and require all possible vegetation to hold them on the land, to give adequate protection against sedimentation, and to prevent destruction of wildlife food and cover.

The lands are best suited for upland game, recreational uses, and enjoyment of their scenic beauty.

| Mapping Unit | % Slope | ADP Code | Mapping Unit | % Slope | ADP Code | Mapping Unit | % Slope | ADP Code |
|---|---|---|---|---|---|---|---|---|
| Discovery Bay vgsl | 50-80 | 81337 | Olele vgsil | 65+ | 81337 | | | |

Land Capability Unit VIIes38 (VIIIe2) is made up of active sand dunes, which consist of deep and coarse textured sand; there is no true soil present. They may need stabilization practices to prevent wind erosion.

The lands have little use except as wildlife or recreational areas.

| Mapping Unit | % Slope | ADP Code |
|---|---|---|
| Active sand dunes | | 81338 |

Land Capability Units VIIIew39, ws00, 22, 23, 24; s00 (VIIIw1) consist of soils and miscellaneous land types that vary from coastal beach to moss peat. There is great variation in water-holding capacity, but all have limitations related to wetness or overflow, or to the soil conditions within the units.

Many of the soils are useful for wildlife food and cover, and for recreational areas.

| Mapping Unit | % Slope | ADP Code | Mapping Unit | % Slope | ADP Code | Mapping Unit | % Slope | ADP Code |
|---|---|---|---|---|---|---|---|---|
| Coastal beach | | 81239 | Marsh complex | | 82323 | Spalding peat | | 82324 |
| Fresh water marsh | | 82322 | Orcas peat | | 82324 | Tidal marsh | | 82323 |
| Gravel pits | | 83000 | Orcas peat, shallow/ gravel | | " | | | |
| Greenwood peat | | 82324 | | | | | | |
| Made land | | 83000 | Riverwash | | 82300 | | | |

1/ Soil symbols used:

| | | | |
|---|---|---|---|
| c | clay | r | rocky |
| co | coarse | s | sandy |
| f | fine | si | silt |
| g | gravelly | st | stony |
| l | loam | v | very |

* An asterisk indicates a benchmark soil. A benchmark soil is one that, because of its great extent or key position in the soil classification system, or both, is important in determining and understanding the variety of soil conditions in a State or other area.

# SUITABILITY OF SOILS FOR WOODLANDS

The Puget Sound Area is generally characterized by a complex pattern of soils. Farmland has been developed largely on the bottom land and terrace soils, while woodlands usually occupy the less fertile, hilly, and steeper soil areas.

Table 12 is concerned with woodland use of soils. Each soil has a characteristic potential productivity, distinct problems of management, and particular reactions to conservation treatments. Information so far available is brought together here for use by woodland owners in planning their woodland conservation operations.[1]

Ratings are given for Douglas-fir but limited information is also supplied for western hemlock, red alder, and the minor forest understory products. Hazards and equipment limitations are briefly outlined in table. Equipment limitations may changes as new equipment is designed to meet the rapidly changing needs of the logging industry.

# SUITABILITY OF SOILS FOR WILDLIFE HABITAT

Soils of the Puget Sound Area have been placed in six major groups according to their suitability for producing various types of wildlife habitat (see Table 13). This habitat may result from native trees, shrubs, and forbs, or from active land management by landowners and operators.

Three general groups of wildlife common to the area are listed along with the relative local quality of wildlife habitat the soils are capable of producing. The table referred to may be used as a guide in determining which soils are best suited to various game species and indicates broad management practices needed to maintain or improve habitat.

[1] Adapted from Schlots, Fred E., and Quam, Alden N., Soil Survey Interpretations for Woodland Conservation, Progress Report, Puget Sound Trough Area, Washington. USDA, Soil Conservation Service, 1966.

# SUITABILITY OF SOILS FOR SUBURBAN USES

Soils of the Puget Sound Area have been rated relative to their comparative suitability for suburban uses (see Table 14). The purpose of the rating is to provide guidance in selecting residential community, and industrial sites. By selecting sites on soils with the fewest limitations for designated uses, property losses, health hazards, and high construction costs may be minimized; likewise, erosion and sediment hazards may be reduced.

## HOMESITES

Soils with fewest limitations for homesites are very deep, well drained, permeable, nearly level to gently sloping, free from flooding, and with a low slide potential. The soil properties and qualities considered and rated to provide guidance in selecting suitable sites for homes are: drainage class, slope, flood hazard, slide potential, depth to bedrock or some restrictive layer, shrink-swell properties, and bearing capacity when moist or wet.

### Buildings

The capacity of different soils to support loads varies considerably. The bearing strength of individual soils may vary significantly under different moisture conditions. Many soils are stable when dry but lose this quality when saturated with water. The bearing value was rated for moist or wet conditions as applicable for a specific soil.

The slope gradient also has an effect on the stability of foundations and the cost of development, expecially where the slope exceeds about 8 percent. Addition engineering and foundation construction costs may be necessary to overcome slope limitations.

Soils that flood have severe limitations. Periodic flooding of homesites becomes a very serious health hazard, and even a hazard to life, as well as causing costly damages to homes. It should be kept in mind that soils formed on bottom lands were formed by floodwaters. It is known that soils of bottom lands along streams are likely to be flooded—some often, others just once in awhile.

### Landscaping

Suitable soils also will enable the owner to beautify his property with vigorously growing plants. The degree of wetness of many soils influences the desirability of the site for landscaping. Poorly- drained soils need surface or subsurface drainage to remove excess water. The choice of suitable grasses and shrubs that will grow well on wet soils is more limited than for the better drained soils.

**Septic Tanks**

A septic tank system for underground disposal of houshold sewage by the soil consists of a septic tank and its filter field. Tile delivers the effluent throughout the filter field for aeration and disposal. The sewage undergoes anaerobic bacterial action in the septic tank but requires further aerobic treatment in the soil of the filter field.

Soil factors which are considered in determining limitations for filter fields are: depth to seasonally high water tables; depth to impervious layers, such as bedrock or cemented glacial hardpan; flooding hazard or frequency; permeability of soil layers above hardpan or bedrock; slope of land; and texture of the soil into which the effluent will percolate. Soils with the fewest limitations for septic tank filter fields are those that are very deep, well drained, at least moderately permeable, nearly level, and not subject to overflow. Where septic tank filter fields are considered, it should be kept in mind that even though soils may be well drained, the iron contained in the soil may precipitate and clog the septic filter bed, making the system ineffective. Generally, not more than three homes per acre should be built where septic tanks are the means of sewage disposal.

## COMMUNITY USES

**Parks and Playgrounds**

Ratings of soils for parks and playgrounds are based on the limitations for grading and reshaping the land when necessary to accommodate the desired use. Properties considered are slope, drainage class, texture, flooding hazard, depth to bedrock or cemented basal till, and permeability as it would influence sewage disposal. Soils with the fewest limitations are those that are nearly level to gently sloping and are well to excessively drained.

**Golf Courses**

Ratings for golf courses are based on limitations of soils for fairways only. Greens are generally made from hauled-in material of a special mixture and are not included in these ratings. However, knowledge of the kind of soil at a proposed greens site will give a good indication of the suitability of the location, particularly with reference to slope, drainage, and flooding or overflow conditions. Generally, slopes steeper than 30 percent have very severe limitations but may be acceptable if of short length and advantageously located on the course. Likewise, most poorly-drained soils are rated as having very severe limitations but may be tolerated if the area is of small size and located in a desirable place. Soils with moderately fine and fine textured layers have been rated as having moderate to very severe limitations because they remain wet longer after a rain than coarser textured soils.

### Sanitary Land Fills

Sanitary land fills are disposal areas for refuse, such as garbage and trash. The waste is placed in a pit or excavation, compated, and covered with about six inches of soil at regular intervals. This is repreated until the trench or disposal area is filled. Continual covering eliminates breeding places for flies, rats, or other disease-bearing insects or animals. Finally, the area is covered with soil sufficiently thick (usually about 24 inches) to insure sanitary conditions and to support vegetation after operations are completed.

Limitations of soils for sanitary land fills are determined by the individual characteristics and qualities of drainage, slope, texture, depth, and flood hazard. Surface water should be handled so as to prevent sedimentation in nearby waters. Soils that are well drained, free from flooding, have moderate slope, are more than 15 feet to bedrock, and have coarse to medium textures, have the fewest limitations for establishment of land fill disposal areas.

### Cemeteries

Soils for cemetery sites are rated upon their stability, drainage, depth to bedrock or cemented glacial till, slope of land, and flood hazard. The soils best suited for cemeteries are deep, well drained, and moderately coarse to moderately fine textured. The soils should be free from overflow and free of seepage from areas lying at higher elevations.

## INDUSTRIAL SITES

While soils of almost any drainage class or slope class may be prepared for industrial sites, soils have been rated to indicate intensity of limitations caused by instability of soils with reference to their load-carrying capacity, shrink-swell potential, drainage, susceptibility to flooding, and slope. Soils best suited for industrial sites are those which have high load-carrying capacities and occur on gentle to nearly level slopes. The soils should have good drainage or be provided with adequate drainage to eliminate the possiblity of contaminating other areas.

## SMALL FARMS AND GARDENS

Generally, soils for small farms and gardens are rated as to suitability the same way agricultural lands are rated—by land capability classes. The ratings are based upon slope, erosion hazards, soil permeabilities, degree of wetness, and susceptibility to flooding.

## CORROSIVE EFFECT OF SOILS

Structural materials corrode when they are buried in soil; and a given material will corrode in some soils more rapidly than in others. The potential corrosivity of each soil for steel and concrete has been evaluated as very low, low, moderate, high, and very high.

Table 12. Woodland suitability groupings of soils with interpretations for management and treatment, Puget Sound Area.

| Soil and Group Description 1/ | Slope Classes 2/ | Erosion Hazard 3/ | Equipment Limitations 4/ | Windthrow Hazard 5/ | Potential Soil Productivity Average site index 6/ Douglas-fir | Potential Soil Productivity Average site index 6/ Red alder | Potential for Minor Understory Forest Products 7/ | Brush Encroachment 8/ | For Douglas-fir Christmas tree Potential 9/ |
|---|---|---|---|---|---|---|---|---|---|
| Group 1. Moderately deep and deep well drained and somewhat excessively drained terrace and bottomland soils with medium and moderately coarse textured surfaces, moderately coarse textured subsoils, and coarse textured substrata. Permeability is moderately rapid in the subsoils and rapid in the substrata. Annual precipitation is 70 to 120 inches. | A and B<br>C and D<br>E and over | Slight<br>Moderate<br>Severe | Slight<br>Moderate<br>Severe | Slight | 182 (4) | 95-104* | Medium | Moderate | Low |
| | | | | Soils of Woodland Suitability Group 1 are: Sol Duc gl and gsl. 10/ | | | | | |
| Group 2. Deep, well drained and moderately well drained glacial terrace and upland soils with medium and moderately coarse textured surfaces and subsoils. Permeability is moderate to moderately rapid. Annual precipitation ranges between 35 to 65 inches. | A and B<br>C and D<br>E and over | Slight<br>Moderate<br>Severe | Slight to Moderate<br>Moderate<br>Severe | Slight | 171 +6 (21) | 106 (1) | Medium | Moderate to Severe | Low |
| | | | | Soils of Woodland Suitability Group 2 are: Giles l, sil, g (subsoil), fsl, and sl; Giles-Tromp Complex; Indianola sl (compact substratum); fsl, ls (compact substratum); Lynden l; Lystair sl; and Oso l, sl and sl (deep). | | | | | |
| Group 3. Moderately deep and deep, moderately well drained and well drained upland and glacial terrace soils with medium, moderately coarse and moderately fine textured surfaces, medium, moderately coarse and moderately fine textured subsoils, and overlying bedrock, cemented glacial till or fine textured substrata. Permeability is moderate to moderately slow in the subsoils and slow to very slow in the substrata. Few fine roots penetrate the substrata. Annual precipitation is 40 to 70 inches. | A and B<br>C and D<br>E and over | Slight to Moderate<br>Moderate<br>Severe | Moderate to severe<br>Severe<br>Severe | Moderate | 160 +5 (68) | 99 (1) | Low to Medium | Moderate to Severe | Low |
| | | | | Soils of Woodland Suitability Group 3 are: Alderwood l, sil; Bow l, sil, gl, cl, sicl; Cathcart l, cl, gl, sil; Enumclaw l, fsl, sl; Fidalgo rl; Heisler gl, l (shaly), stl; Jolley vgl; Kapowsin gl, gcl; Kickerville sil; Kitsap l, sil, sicl; Kline l, gl; La Bounty sil; Marblemount stl; Melbourne l; Saxon sil; Schnorbush l; Shelton gl; Squalicum sil, gsil; Tebo l, gl, sicl; Whatcom sil; and Wilkeson l and sil. | | | | | |

* "Starred" values are adjusted values which more nearly represent the true average site index, in the best judgment of the authors, where adequate site index information was not available.

Table 12. Woodland suitability groupings of soils with interpretations for management and treatment (con.)
Puget Sound Area.

| Soil and Group Description 1/ | Slope Classes 2/ | Erosion Hazard 3/ | Equipment Limitations 4/ | Windthrow Hazard 5/ | Potential Soil Productivity Average site index 6/ Douglas-fir | Potential Soil Productivity Average site index 6/ Red alder | Potential for Minor Understory Forest Products 7/ | For Douglas-fir Brush Encroachment 8/ | For Douglas-fir Christmas tree Potential 9/ |
|---|---|---|---|---|---|---|---|---|---|
| Group 4. Deep, somewhat excessively drained glacial terrace soils with medium and moderately coarse textured surfaces and moderately coarse textured subsoils. Permeability of the subsoils is rapid. Annual precipitation ranges between 35 and 55 inches. | A and B | Slight | Slight | Slight | 160 ±6 (20) | | Low to Medium | Slight to Moderate | Low to Medium |
| | C and D | Moderate | Moderate | | | | | | |
| | E and over | Severe | Severe | | | | | | |
| | | | | Soils of Woodland Suitability Group 4 are: Barneston sil; Corkindale l; Everett gl, gsl; Klaus sl, gl, gsl; Kline sil, sl; Snoqualmie gsl, gl; Thornwood gl; and Wickersham l (shaly). | | | | | |
| Group 5. Deep and moderately deep, well drained and moderately well drained glacial terrace and upland soils with medium, moderately fine and moderately coarse textured surfaces and subsoils, and overlying cemented glacial till, clay till or bedrock. Permeability is slow to moderate in the subsoils and very slow to slow in the substratum. Annual precipitation ranges between 35 to 70 inches. | A and B | Slight | Moderate | Moderate | 145 ±8 (100) | 84 (1) | Medium | Moderate to Severe | Low |
| | C and D | Moderate | Severe | | | | | | |
| | E and over | Severe | Severe | | | | | | |
| | | | | Soils of Woodland Suitability Group 5 are: Alderwood gsl, gl, stl; Cathcart gsl, fsl, stl; Discovery Bay gsl; Gilligan l, sil, sil (shallow), gl (shallow); Harstine gsl; Kapowsin gsl; Nordby l; Orting l, sl, gsl, stsl; Pickett-Rock complex; Quilcene sicl; Shelton gsl; Skiyou gl; and Squalicum stsil. | | | | | |
| Group 6. Shallow and moderately deep, poorly drained and imperfectly drained glacial basin soils with medium and moderately coarse textured surfaces, iron cemented subsoils, and coarse textured substrata. Permeability of the subsoil is slow to very slow. Annual precipitation is 40 to 50 inches. | A and B | Slight | Slight | Moderate | 140 ±2 (3) | | Medium | Severe | Severe |
| | C and D | Moderate | Moderate | | | | | | |
| | | | | Soils of Woodland Suitability Group 6 are: Cagey gl, gfsl, gsl, sil, sl; Custer sil, fsl, sl; Edmonds l, sil, sl, fsl; Hale sil; Hale-Norma complex; Hemmi sil; Tromp sil, sicl; and Woodlyn sil. | | | | | |
| Group 7. Deep, excessively drained and somewhat excessively drained glacial terrace soils with moderately coarse textured surfaces and coarse textured subsoils. Permeability is rapid to moderately rapid. Annual precipitation is 35 to 65 inches. | A and B | Slight | Slight | Slight | 137 ±8 (67) | 96 (2) | Low to Medium | Slight to Moderate | Low to Medium |
| | C and D | Moderate | Moderate | | | | | | |
| | E and over | Severe | Severe | | | | | | |
| | | | | Soils of Woodland Suitability Group 7 are: Barneston gsl; Dick lfs; Everett sl (cobbly), stsl, gls, Grove gl (basin), l, gl, sl, gsl (basin); Indianola sil, sl; Lynden sl, gl, gsl; Nisqually s, ls; Ragnar fsl; Skykomish gsl, sl (cobbly), gl, stl; Smith Creek gl; Spanaway gsl; Tenino gsl; Thornwood gsl; and Tumwater fsl, lfs. | | | | | |

Table 12. Woodland suitability groupings of soils with interpretations for management and treatment (con.) Puget Sound Area.

| Soil and Group Description 1/ | Slope Classes 2/ | Erosion Hazard 3/ | Equipment Limitations 4/ | Windthrow Hazard 5/ | Potential Soil Productivity Average site index 6/ Douglas-fir | Potential Soil Productivity Average site index 6/ Red alder | Potential for Minor Understory Forest Products 7/ | For Douglas-fir Brush Encroachment 8/ | For Douglas-fir Christmas tree Potential 9/ |
|---|---|---|---|---|---|---|---|---|---|
| Group 8. Moderately deep, well drained and somewhat excessively drained glacial terrace and upland soils with medium textured and moderately coarse textured surfaces and subsoils overlying cemented glacial till or bedrock. Permeability is moderate to rapid. Average annual precipitation ranges between 48 and 65 inches. | A and B | Slight | Slight to Moderate | Moderate | 130 ±6 (28) | | Low to Medium | Moderate | Medium |
| | C and D | Moderate | Moderate | | | | | | |
| | E and over | Severe | Severe | | | | | | |
| | | | | Soils of Woodland Suitability Group 8 are: Delphi gl; Hoodsport gsl, vgsl, stsl; Olete vgsil; and Whidbey gsl. | | | | | |
| Group 9. Moderately deep to shallow, poorly drained and imperfectly drained glacial terrace and upland soils with moderately fine and medium textured surfaces and moderately fine and fine textured subsoils. Some soils have cemented glacial till or bedrock substrata. Permeability is slow to very slow. Annual precipitation ranges between 25 and 45 inches. | A and B | Slight | Moderate | Moderate | 114 ±11 (23) | 81 (1) | Low | Moderate to Severe | Low to Medium |
| | C and D | Moderate | Severe | | | | | | |
| | E and | Severe | Severe | | | | | | |
| | | | | Soils of Woodland Suitability Group 9 are: Bow l (shallow), sil, sil (shallow), gsil, stsil; Buckley l, sil; Casey l, fsl, sil; Cloquallum sil, sicl; Coveland l, sil, gl, gsil, stsil; Kitsap sicl, gl; and Stossel cl, stl. | | | | | |
| Group 10. Moderately deep, deep and shallow, well drained and moderately well drained glacial terrace soils with medium and moderately coarse textured surfaces, moderately coarse textured subsoils, and cemented glacial till substrata. Permeability of the subsoils is moderately rapid and the substrata is slow. Few roots penetrate into the substrata. Annual precipitation is 25 to 65 inches | A and B | Slight | Moderate | Moderate | 106 ±7 (57) | 75-84* | Low to Medium | Slight to Moderate | Low to Medium |
| | C and D | Moderate | Severe | | | | | | |
| | E and over | Severe | Severe | | | | | | |
| | | | | Soils of Woodland Suitability Group 10 are: Agnew sil, sicl; Alderwood gsl (red phase), gsl, gsl (shallow), gl (shallow), ls; Bozarth fsl; Clallam l, gl, gsl; Cloquallum sil (moderately shallow); Discovery Bay vgsl; Grove gsl, vgsl; San Juan stl (moderately deep), gsl (moderately deep); Sinclair l (shotty), cl (shotty), gsl, gfsl, gl; Swantown l, gsl; Tokul gsl; Townsend l, sl, gl; and Whidbey gsl. | | | | | |
| Group 11. Deep, somewhat excessively drained glacial terrace soils with moderately coarse and coarse textured surfaces, and coarse textured subsoils. Permeability is rapid. Annual precipitation ranges between 35 to 70 inches | A and B | Slight | Slight | Slight | 109 ±6 (66) | | Medium to High | Slight | High |
| | C and D | Moderate | Moderate | | | | | | |
| | E and over | Severe | Severe | | | | | | |
| | | | | Soils of Woodland Suitability Group 11 are: Barneston gfsl; Carstairs gl; Chimacum gl. gsl; Dick ls, ls (complex); Everett stls; Fitch gsl; Hoypus cosl, gls; Indianola ls, lfs; Keystone fsl, ls; Lynden ls; Lystair fsl, ls; San Juan cosl, gsl, stsl; Skykomish gs, sts; and Snoqualmie gls. | | | | | |

Table 12. Woodland suitability groupings of soils with interpretations for management and treatment (con.)
Puget Sound Area.

| Soil and Group Description 1/ | Slope Classes 2/ | Erosion Hazard 3/ | Equipment Limitations 4/ | Windthrow Hazard 5/ | Potential Soil Productivity Average site index 6/ Douglas-fir | Red alder | Potential for Minor Understory Forest Products 7/ | For Douglas-fir Brush Encroachment 8/ | Christmas tree Potential 9/ |
|---|---|---|---|---|---|---|---|---|---|
| **Group 12**. Moderately deep, moderately well drained, glacial terrace soils with medium and moderately coarse textured surfaces, and moderately fine textured subsoils. Permeability is slow. Annual precipitation is 22 to 28 inches. | A and B | Slight | Moderate ) | Moderate | 108 ±10 (44) | 75 (8) | Low | Moderate | Medium |
| | | | | Soils of Woodland Suitability Group 12 are: Elwha l; Roche l, gsl, gl, stl, stsl; and Roche-Rock complex. | | | | | |
| **Group 13**. Deep, somewhat excessively drained glacial terrace soils with very gravelly and cobbly moderately coarse textured surfaces and subsoils, and coarse textured substrata. Permeability is rapid to very rapid. Annual precipitation is 70 to 100 inches. | A and B | Slight | Slight ) | Slight | 87 ±5 (4) | | High | Slight | High |
| | C and D | Moderate | Moderate ) | | | | | | |
| | | | | Soils of Woodland Suitability Group 13 are: Grove vgsl, stsl, sl(cobbly). | | | | | |
| **Group 14**. Moderately deep, poorly drained upland and terrace soils with medium textured surfaces, and moderately fine and fine textured subsoils. Permeability is slow. Annual precipitation is 90 to 120 inches. | A and B | Slight | Severe ) | | | | | | |
| | C and D | Moderate | Severe ) | | | | | | |
| | E and over | Severe | Severe ) | Sitka Spruce, Western Hemlock, Western Red Cedar, and Red Alder are adapted to Hoko soils and Douglas-fir to Nasel soils. | | | | | |
| **Group 15**. Deep, excessively and somewhat excessively drained bottomland soils with moderately coarse and coarse textured surfaces, and coarse textured subsoils. Permeability is rapid to very rapid. Most of these soils are subject to overflow. | A and B | Moderate to Severe | Slight ) | Slight | Black cottonwood and Big Leaf Maple adapted to these soils. | | Low | Moderate | Low |
| | | | | Soils of Woodland Suitability Group 15 are: Edgewick s; Greenwater s; *Pilchuck sl*, fsl, ls, gls, fs, lfs, lfs (shallow), s, gs; and Riverwash. | | | | | |
| **Group 16**. Moderately deep and shallow, poorly drained bottomland and glacial basin soils with moderately coarse, medium, and moderately fine textured surfaces, and fine textured subsoils. Runoff is slow to very slow and permeability is very slow. Water remains on the surface 8 months or more unless drained. Where drained, these are agricultural soils. | A and B | | | | 131 10 ± (5) | 82 (1) | Most suitable for Sitka Spruce, Western Red Cedar, Western Hemlock, Willows, and Sedges. | | |
| | | | | Soils of Woodland Suitability Group 16 are: Bellingham l, sicl, cl, sil, fsl, c, sic; Clipper sicl; Everson sil, fsl, cl; Hovde sicl, s, ls; Issaquah sil; Kopiah l, sicl; Lummi sil, sicl; McKenna l, sicl, gcl, gl; Norma l, cl, sl, sil, sicl, fsl, sic: Nookachamps sil, sicl; Nuby sil; Puget cl, c, sic; Reed sicl; Shuwah sicl; Skagit sicl; Snohomish l, sil, sicl, fsl, sic, lfs; *Thornton c*, sicl; Tisch sil, sicl; Wapato sil, sicl, cl; and Woodinville sil. | | | | | |

Table 12. Woodland suitability groupings of soils with interpretations for management and treatment (con.)
Puget Sound Area

| Soil and Group Description 1/ | Slope Classes 2/ | Erosion Hazard 3/ | Equipment Limitations 4/ | Windthrow Hazard 5/ | Potential Soil Productivity Average site index 6/ Douglas-fir | Potential Soil Productivity Average site index 6/ Red alder | Potential for Minor Understory Forest Products 7/ | For Douglas-fir Brush Encroachment 8/ | For Douglas-fir Christmas tree Potential 9/ |
|---|---|---|---|---|---|---|---|---|---|
| Group 17. Deep somewhat excessively drained bottomland and low terrace soils with medium, moderately coarse and coarse textured surfaces, and coarse textured subsoils. Permeability is rapid to very rapid. Some of the soils are subject to periodic overflow. Annual precipitation ranges between 16 and 100 inches. The soils are droughty. Some are irrigated. | | | | | | | Most of these droughty soils have been cleared for cultivation. No tree productivity information is known to be available. | | |
| | | | | Soils of Woodland Suitability Group 17 are: Edgewick sil, fsl, vfsl; Greenwater sl, ls; National l (pumicy), sl (pumicy); Neptune sl; Newberg l, fsl, ls; Pilchuck sil; Puyallup sl, fsl, ls (over Puget), lfs; and Snakelum cosl. | | | | | |
| Group 18. Deep, moderately deep, and shallow, very poorly drained organic soils underlain by sand, silt or clay. Moderately to moderately slowly permeable. Very slow runoff. | | | | | | 101 (1) | Organic soils that generally are not suited to Douglas-fir, Alder, Hemlock and Shore Pine have been observed. | | |
| | | | | Soils of Woodland Suitability Group 18 are: Carbondale muck, muck (shallow); Dupont muck; Greenwood peat; Mukilteo peat; McMurray peat, peat (shallow); Orcas peat; Rifle peat (McMurray); Semiahmoo muck, muck (shallow), muck (shallow over Mukilteo);Spalding peat, peat (burned phase); Tacoma muck(shallow; Tanwax muck; and Tidal marsh. | | | | | |
| Group 19. Deep, well drained and moderately well drained bottomland and low terrace soils with medium and moderately fine and moderately coarse textured surfaces and subsoils. Permeability is moderate to moderately rapid. Annual precipitation is 20 to 70 inches. (Soils in this group are used mainly for agricultural purposes.) | A and B | | | | 173 (2) | | Used mainly for agriculture. No tree production activity is known to be available. | | |
| | | | | Soils of Woodland Suitability Group 19 are: Belfast sil, sl; Chehalis sil; Cokedale l, sl, sil, sil (over Puyallup), sicl (over Puyallup); Coupeville l, sil; Dungeness l, sil; Ebeys sl; Eld l, sicl, gl; Nooksack sil, fsl; Puget l, sil, sicl, fsl, vfsl; Puyallup l, sil, sicl, sl (shallow over Buckley), vfsl; Salal sil, fsl; Samish sicl; Sammamish sil; Sauk l; Sequim gl; Sultan l, cl, sil, fsl; and Sumas sil. | | | | | |

See following page for explanation of symbols.

Table 12.. Woodland suitability groupings of soils with interpretations for management and treatment (con.)
Puget Sound Area.

| Soil Group and Description 1/ | Slope Classes 2/ | Erosion Hazard 3/ | Equipment Limitations 4/ | Windthrow Hazard 5/ | Potential Soil Productivity Average site index 6/ Douglas-fir | Potential Soil Productivity Average site index 6/ Red alder | Potential for Minor Understory Forest Products 7/ | For Douglas-fir Brush Encroachment 8/ | For Douglas-fir Christmas tree Potential 9/ |
|---|---|---|---|---|---|---|---|---|---|

FOOTNOTES:

1/ See Table 3, Index of Mapping Units, for alphabetical listing of soils with their woodland soil groups.

2/ Ranges of slope gradients in percent, segregated and identitied as follows: A, 0-3%; B, 3-8%; C, 8-15%; D, 15-30%; E, 30-45%; F, 45% plus.

3/ Erosion Hazard: Slight - No special problem.
Moderate - Some measures required.
Severe - Intensive use of control measures.

4/ Equipment Limitations: Slight - No special problems.
Moderate - Restrictions during wet weather.
Severe - Long restricted periods.

5/ Windthrow Hazard: Slight - No special problems.
Moderate - Moderate thinning permissable.
Severe - Thinning may induce severe hazard.

6/ First figures denote average site index as determined from the sample data; second (plus or minus) figures indicate standard deviation of the data; figures in parentheses indicate size of sample (number of sample plots). For practical use, this average value should be regarded as the approximate central value of a site quality class with an approximate range indicated by the standard deviation where this is shown. Where there were not enough plots to calculate a standard deviation the approximate range should be regarded as about plus or minus 10. It is assumed that the average values shown and their approximate ranges apply to all soils within each group even though they were not all sampled.

7/ Raw products of the forest, other than logs, poles, and pulpwood; in this case, principally floral greenery and cascara bark.
Low - Usually submarginal harvest.
Medium - Harvest less than annual interval.
High - Usually good annual harvest.

8/ Brush Encroachment: Slight - No special problem
Moderate - Slows initial growth of Douglas-fir, delays development.
Severe - Immediate and severe competition reduces survival of Douglas-fir.

9/ The relative suitability for producing Christmas trees of salable quality <u>without</u> cultural treatment. The higher sites will often produce better Christmas trees under intensive cultural treatment.
Low - Rapid growth, poor quality, excessive cultural treatment required.
Medium - Moderate cultural treatment required for quality.
High - Quality product without cultural treatment.

10/ Abbreviations of soils are as follows:

| | | | | | |
|---|---|---|---|---|---|
| c | clay | l | loam | si | silt |
| co | coarse | r | rocky | st | stony |
| f | fine | s | sandy | v | very |
| g | gravelly | | | | |

Table 13. Suitability of soils for wildlife food and cover, Puget Sound Area.

| Soils by groups | Suitability of soils for uses cited | | | | | | | Remarks |
|---|---|---|---|---|---|---|---|---|
| | Food and cover | | | | Wildlife | | | |
| | Trees | Shrubs | Forbs | Cultivated | Deer | Birds | Waterfowl | |
| __Group 1__<br>Deep, well-drained, and somewhat excessively drained terraces and uplands.<br>Barneston, Barneston-Wilkeson, Bernhardt, Carlsborg, Chimacum, Cinebar, Cispus, Corkindale, Crescent, Dick, Ebeys, Everett, Fitch, Giles, Gilligan, Gravel Pits 2/, Greenwater, Grove, Hoypus, Indianola, Keystone, Kickerville, Klaus, Lynden, Lystair, National, Nesika, Nisqually, Nordby, Pondilla, Ragnar, San Juan, Sauk, Skykomish, Smith Creek, Snoqualmie, Sol Duc, Spanaway, Thornwood, Tumwater | Douglas-fir | Blackberry, huckleberry, elderberry, and Oregon grape | Bracken fern, sword fern, moss, and twinflower | Pasture, hay, small grain, canefruit, strawberries and vegetables 1/ | Good | Quail, grouse, doves, pheasants -- good to excellent | Not suited | 1/ Cultivated category applies only on slopes of less than 15%. Slopes over 15% are suited for trees, shrubs and forbs.<br>2/ Gravel pits unsuited for cultivation. |
| __Group 2__<br>Moderately shallow, somewhat poorly and moderately well-drained upland and terrace soils.<br>Agnew, Agnew-Elwha, Ahl, Alderwood, Astoria, Bow, Bozarth, Cagey, Casey, Cathcart, Clallam, Cloquallum, Colvos, Colvos-Kitsap complex, Coupeville, Coveland, Dabob, Delphi, Discovery Bay, Discovery Bay - Rock outcrop complex 3/, Discovery Bay - Hoodsport 3/, Elwha, Enumclaw, Fidalgo 3/, Hale, Harstine, Heisler, Kapowsin, Kitsap, Marblemount 3/, Melbourne, Olele 3/, Olympic, Orting, Oso, Pickett, Prather, Quilcene, Roche, Rockland 3/, Rough broken land 3/, Rough mountainous land, Oso materials 3/, Rough stony land 3/, Rough broken land, Olympic materials 3/, San Juan, moderately deep, Saxon, Schnorbush, Shelton, Sequim, Sinclair, Skiyou, Squalicum, Steep broken land 3/, Stossel, Swantown, Tebo, Tenino, Tokul, Townsend, Triton, Waddell, Whatcom, Whidbey, Wickersham, Wilkeson | Douglas-fir, red alder, cedar, hemlock, birch, and big leaf maple -- fairly good. | Salal, Oregon grape, snowberry, thimble-berry, elderberry, blackberry, vine maple, and wild rose -- good. | Bracken fern, sword fern -- good. | Grasses, legumes, small grain, vegetables, and canefruit 1/ | Good | Pheasant, quail, grouse -- fair for nesting; fairly good for cover. | Not suited | 1/ Cultivated category applies only on slopes of less than 15%. Slopes over 15% are suited for trees, shrubs and forbs.<br>3/ These soils generally unsuited for cultivation because of stoniness, rock outcrops, shallowness, and/or slope. |

Table 13. Suitability of soils for wildlife food and cover, Puget Sound Area (con.)

| Soils by groups | Suitability of soils for uses cited: Food and cover — Trees | Shrubs | Forbs | Cultivated | Wildlife — Deer | Birds | Waterfowl | Remarks |
|---|---|---|---|---|---|---|---|---|
| **Group 3**<br>Shallow and moderately shallow, poorly drained, moderately fine and moderately coarse textured terrace basin soils.<br>Bellingham, Buckley, Cagey-Norma, Clackamas, Clipper, Custer, Edmonds, Everson, Hemmi, Kopiah, McKenna, Norma, Reed, Schooley, Skagit, Thornton, Tromp, Woodlyn | Red alder, cedar, birch, hemlock, Douglas-fir, cottonwood and big leaf maple | Blackberry, ocean spray, snowberry, and wild rose | Bracken fern | Grasses and legumes -- suited for wetlands 4/ | Good | Pheasants, quail, grouse -- fairly good for food; poor for nesting. | Undrained soils are fair for nesting, good for food. Drained soils are not suited for nesting, good for food. | 4/ Drainage generally required for cultivated uses. |
| **Group 4**<br>Poorly drained and very poorly drained organic soils consisting of peats and mucks.<br>Carbondale, Dupont, Fresh water marsh 6/, Greenwood 6/, Hovde 6/, McMurray, Orcas 6/, Spalding, Tacoma, Tanwax, Tidal Marsh 6/, Tisch | Cedar, hemlock, and lodgepole pine. Tidal marsh cover consists of salt, grasses and shrubs. | Ocean spray and blackberry | | Where drained: suited for grasses, legumes and vegetables 5/ | Where drained: fairly good for browse. Where undrained: not suited. | Where drained fairly good for food; fair to poor for nesting. Where undrained: fair for food. Not suited for nesting. | Where drained: fairly good for nesting, food and cover. Where undrained: good for food and nesting. | 5/ Drainage and water control necessary for cultivated uses.<br>6/ These soils and land forms unsuited for cultivated uses because of fertility and/or saltiness. |
| **Group 5**<br>Deep and poorly drained and somewhat poorly drained, moderately fine and fine textured bottomland soils subject to flooding.<br>Alluvial soils, undifferentiated, Belfast, Chehalis, Cokedale, Dungeness, Issaquah, Koch, Lummi, Maytown, Nookachamps, Nooksack, Nuby, Puget, Sammamish, Shuwah, Skokomish, Snohomish, Sultan, Sumas, Wapato, Woodinville | Cedar, Douglas-fir, hemlock, red alder, | Blackberry, snowberry, and ocean spray | | Grain, grasses, legumes, small grain, and vegetables | Fairly good where drained and protected from flooding. | Pheasants, grouse, quail-poor to not suited for nesting because of periodic flooding. Good for food | Fair to poor for nesting. Good for food. Poor for nesting during flood periods. | |
| **Group 6**<br>Well drained and somewhat excessively drained, moderately coarse and coarse textured bottomland soils subject to flooding.<br>Camas, Edgewick, Juno, Kline, Neptune, Newberg, Pilchuck, Puyallup, Salal, Coastal Beach 7/, Riverwash 8/ | Douglas-fir, big leaf maple, cottonwood, red alder, and vine maple | Blackberry, huckleberry, elderberry, Oregon grape, and snowberry | | Grasses, legumes, small grain, canefruit, strawberries corn, vegetables and vegetable seed | Good where protected from floods. Not suited while flooding. | Good for food and cover. Good nesting sites where protected from flooding. Poor nesting sites where unprotected and subject to flooding. | Not suited because soils are droughty. May be suited for nesting except when flooding | 7/ Coastal beach unsuited for cultivation. Best suited for game preserve.<br>8/ Riverwash unsuited for cultivation and crop or wood production because of frequent flooding and requires all possible vegetation for watershed protection. |

Table 14. Comparative suitability of soils for suburban uses, Puget Sound Area.

| Soil Series and Type | Suitability of Soils for Uses Cited 1/ | | | | | | | | | | Corrosive Effect of Soil on | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Homesite | | | Community | | | | | Other | | | |
| | Buildings | Land-scaping | Septic Tanks | Parks | Golf Courses | Sanitary Land Fill | Ceme-teries | Sewage Lagoons | Indus-trial | Small Farms and Gardens | Uncoated Steel | Concrete |
| Active dune land | D: unstable soils | C: unstable & low moisture | B: unstable | C: unstable & low moisture | C: unstable & low moisture | D: unstable | D: unstable | D: rapid perme-ability, 5.0-10.0 in/hr. | A | D: low moisture | Moderate | Moderate |
| Agnew-Elwha com-plex (see Elwha silt loam) | C: high shrink-swell | A | D: perme-ability, 0.2-0.8 in/hr. | A | A | B: imperfect drainage | B: imperfect drainage | B: severe piping hazard | B: soil moisture control; high shrink-swell | A | High | Moderate |
| Agnew silt loam<br>Agnew loam<br>Agnew fine sandy loam<br>Agnew sandy loam<br>Agnew silty clay loam | C: high shrink-swell | A | D: perme-ability, 0.2-0.8 in/hr. | A | A | B: imperfect drainage | B: imperfect drainage | B: severe piping hazard | B: soil moisture control; high shrink-swell | A | Moderate<br>High | Low<br>Moderate |
| Ahl very gravelly silt loam | C: slope & texture of soil | A | D: slope | D: slopes over 30% | D: slope | D: bedrock | D: bedrock and slope | D: slope | D: slope | D: slope | High | Low |
| Alderwood gravelly loam | | | | | | | | | | | Moderate | Moderate |
| 0-15%<br>15-30%<br>over 30% | B: soil<br>C: slope<br>D: slope | A<br>A<br>D: slope | D: perme-ability, 0.05-0.2 in/hr. | A<br><br>D: slope | A: 0-15%<br>B: 15-25%<br>D: over 25% | D: cemented<br>D: glacial<br>D: till | C: cemented glacial till & wet<br>D: slope | B: piping hazard<br>D: slopes over 3% | A<br><br>D: slope | A<br>C: slope<br>D: slope | | |

1/ Suitabilities for specified uses are indicated:
A: slight limitations
B: moderate limitations
C: severe limitations
D: very severe limitations

Table 14. Comparative suitability of soils for suburban uses, Puget Sound Area (con.)

| Soil Series and Type | Suitability of Soils for Uses Cited 1/ | | | | | | | | | | Corrosive Effect of Soil on | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Homesite | | | Community | | | | | Other | | | |
| | Buildings | Land-scaping | Septic Tanks | Parks | Golf Courses | Sanitary Land Fill | Ceme-teries | Sewage Lagoons | Indus-trial | Small Farms and Gardens | Uncoated Steel | Concrete |
| Alderwood silt loam 0-15% | A | A | D: perme-ability, 0.05-0.2 in/hr. | A | B: slope | D: cemented glacial till | B: cemented till | D: slopes over 15% | A | A | Moderate | Moderate |
| Alderwood loam 0-15% | A | A | D | A | B: slope | D: ce-mented gla-cial till | D: slope | D | A | A | Moderate | Moderate |
| Alderwood gravelly sandy loam Alderwood fine sandy loam Alderwood loamy sand | | | | | | | | | | | Moderate | Moderate |
| 0-15% | B: soil | A | D: perme-ability, 0.05-0.2 in/hr. | A | A | D: cemented glacial till | C: cemented glacial till & wet | B: piping | A | A | | |
| 15-30% | C: slope | A | | A | B | | D: slope | D: slopes over 3% | B: slope | C: slope | | |
| over 30% | D: slope | D: slope | | D: slope | D: slope | | | | | | | |
| Alderwood stony loam 0-15% | C: soil texture | | D: perme-ability, 0.05-0.2 in/hr. | | | | | D: slope | B: slope | D: soil texture | Moderate | Moderate |
| 15-30% | D: slope & soil texture | D: slope & soil texture | | D: slope | D: slope & soil texture | D: ce-mented gla-cial till | D: slope & soil texture | D: slope | D: slope | D: slope | | |
| Alluvial soils, undifferentiated | D: flooding | D: flooding | D: flooding | D: flooding | D: flooding | D: flooding | D: flooding | D: flooding | D: flood water control | D: flooding | High | Moderate |

Table 14. Comparative suitability of soils for suburban uses, Puget Sound Area (con.)

| Soil Series and Type | Suitability of Soils for Uses Cited 1/ | | | | | | | | | | Corrosive Effect of Soil on | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Homesite | | | Community | | | | | Other | | | |
| | Buildings | Land-scaping | Septic Tanks | Parks | Golf Courses | Sanitary Land Fill | Cemeteries | Sewage Lagoons | Industrial | Small Farms and Gardens | Uncoated Steel | Concrete |
| Astoria silt loam 8-15% | B: unstable soils | A | D: permeability, 0.05-0.2 in/hr. | A | A | D: bedrock | D: bedrock | D: slope | B: soil moisture control. Low stability & shrink-swell dangerous. | B: slope | High | Moderate |
| 15-30% | D: unstable soils & slopes | C: slope | | C: slope | D: slope | | | | D: slope | D: slope | | |
| Barneston gravelly fine sandy loam<br>Barneston gravelly loamy sand<br>Barneston gravelly sandy loam | | | | | | | | | | | Very low | Moderate |
| 0-3% | A | A | A | A | A | A | A | | A | C: low | | |
| 3-8% | A | A | A | A | A | A | A | D: permeability, 5.0-10.0 in/hr. | A | C: moisture | | |
| 8-15% | B: slope | A | A | B: slope | B: slope | B: slope | B: slope | | B: slope | D: low | | |
| 15-30% | C: slope | B: slope | D: slope | D: slope | D: slope | D: slope | D: slope | | D: slope | D: moisture & slope | | |
| Barneston silt loam | | | | | | | | | | | Low to very low | Moderate |
| Barneston-Wilkeson complex (see Wilkeson silt loam for other interpretations) | | | | | | | | | | | Very low | Moderate |
| 3-8% | A | A | A | A | A | A | A | D: permeability, 5.0-10.0 in/hr. Contamination hazard. | A | C: low | | |
| 8-15% | B: slope | A | A | B: slope | B: slope | B: slope | B: slope | | B: slope | C: moisture | | |
| 15-30% | C: slope | C: slope | D: slope | D: slope | D: slope | B: slope | D: slope | | D: slope | D: and slope | | |
| Barneston stony silt loam 8-15% | B: slope | B: slope & soil texture | D: slope | B: slope & soil texture | A | B: slope & soil texture | D: slope & soil texture | D: slope & permeability | D: slope | D: slope & soil texture | Low to very low | Moderate |

Table 14. Comparative suitability of soils for suburban uses, Puget Sound Area (con.)

| Soil Series and Type | Suitability of Soils for Uses Cited 1/ | | | | | | | | | | Corrosive Effect of Soil on | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Homesite | | | Community | | | | | Other | | | |
| | Buildings | Land-scaping | Septic Tanks | Parks | Golf Courses | Sanitary Land Fill | Ceme-teries | Sewage Lagoons | Indus-trial | Small Farms and Gardens | Uncoated Steel | Concrete |
| Barnhardt gravelly silt loam<br>Barnhardt gravelly sandy loam | | | | | | | | | | | Very low | Low |
| 3-8% | A | A | A | A | A | A | A | D: permeability, 5.0-10.0 in/hr. Contamination hazard | A | C: low moisture | | |
| 15-30% | D: slope | D: slope | D: slope | B: slope | B: slope | B: slope | D: slope | | D: slope | D: slope | | |
| Belfast silt loam<br>Belfast silty clay loam | D: flood hazard | B: flood hazard | D: flood hazard | B: flood hazard | B: flood hazard | D: flood hazard | D: flood hazard | D: flood hazard | C: flood water control | B: flood hazard | Moderate | Moderate |
| Belfast fine sandy loam<br>Belfast sandy loam | D: flood hazard | B: flood hazard | D: flood hazard & soil texture | B: flood hazard | B: flood hazard | D: flood hazard | D: flood hazard | D: flood hazard | C: flood water control | B: flood hazard | Low | Moderate |
| Bellingham clay<br>Bellingham silty clay<br>Bellingham clay loam<br>Bellingham silty clay loam<br>Bellingham silt loam<br>Bellingham loam<br>Bellingham fine sandy loam | D: unstable; high shrink-swell | D: wet | D: water table. Soil permeability, less than 0.05 in/hr. | D: wet | D: wet | D: water table | D: water table | D: water table & unstable soil | C: unstable soil; high shrink-swell; soil moisture control | C: wet | Very high | Moderate |

Table 14. Comparative suitability of soils for suburban uses, Puget Sound Area (con.)

| Soil Series and Type | Suitability of Soils for Uses Cited 1/ — Homesite: Buildings | Homesite: Landscaping | Homesite: Septic Tanks | Community: Parks | Community: Golf Courses | Community: Sanitary Land Fill | Community: Cemeteries | Community: Sewage Lagoons | Other: Industrial | Other: Small Farms and Gardens | Corrosive Effect of Soil on: Uncoated Steel | Corrosive Effect of Soil on: Concrete |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Bow loam<br>Bow silt loam<br>Bow silt loam, shallow<br>Bow stony silt loam<br>Bow gravelly loam<br>Bow gravelly silt loam<br>Bow silty clay loam<br>Bow-Bellingham silty clay loams (for Bellingham see above) | | | | | | | | | | | High | Moderate |
| 0-3%)<br>3-8%)<br>8-15%) | C: poor drainage; high shrink-swell | C: wet & shallow soil | D: Permeability, 0.05-0.2 in/h4. | C: wet; shallow soil | B: seasonal wetness | D: cemented glacial till at 24-36''; seasonal water table; slope | D: cemented glacial till at 24-36''; seasonal water table; slope | B: 0-3%. may crack D: slopes over 3% | C: unstable when disturbed. Soil moisture control. | C: shallow soils, seasonal wetness D: over 15% slopes | | |
| 15-30%)<br>over 30%) | D: slope, drainage & shrink-swell | D: slope over 30%; wet, shallow soil | | D: slope over 30%; wet, shallow soil | C: seasonal wetness; 15-30% slope. D: seasonal wetness; over 30% slope | | | | | | | |
| Bow clay loam | | | | | | | | | | | High | Moderate |
| 3-8%)<br>8-15%) | C: poor drainage & high shrink-swell | C: wet & shallow soil | D: permeability, 0.05-0.2 in/hr. | C: wet & shallow soil | B: seasonal wetness C: seasonal wetness | D: cemented glacial till at 24-36''; seasonal water table; slope | D: cemented glacial till at 24-36''; seasonal water table; slope | B: 0-3% may crack D: slopes over 3% | C: unstable when disturbed; soil moisture control | C: shallow soils; seasonal wetness D: over 15% slopes | | |
| 15-30% | D: slope, drainage & shrink-swell | | | | D: seasonal wetness; slope 15-30% | | | | | | | |

Table 14. Comparative suitability of soils for suburban uses, Puget Sound Area (con.)

| Soil Series and Type | Suitability of Soils for Uses Cited 1/ | | | | | | | | | | Corrosive Effect of Soil on | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Homesite | | | Community | | | | | Other | | | |
| | Buildings | Land-scaping | Septic Tanks | Parks | Golf Courses | Sanitary Land Fill | Ceme-teries | Sewage Lagoons | Indus-trial | Small Farms and Gardens | Uncoated Steel | Concrete |
| Bozarth fine sandy loam 0-3/ | B: drainage | B: shallow soil | D: perme-ability, 0.05-0.2 in/hr. | A | A | D: cemented glacial till | D: seasonal water table | C: high piping hazard | A | A | Moderate | Moderate |
| 8-15% | C: slope | B: shallow soil | | A | A | | | D: slope | | C: slope | | |
| Buckley clay loam Buckley silt loam Buckley loam Buckley-Enumclaw loams (see Enum-claw loam) | D: wetness and high shrink-swell | B: wet & shallow soils | D: perme-ability, 0.05-0.2 in/hr. | B: wetness | B: wetness | D: water table and dense substrata | D: water table and dense substrata | A | C: wetness, shrink-swell high-moderate; soil mois-ture control | B: wetness | High | Moderate |
| Cagey sandy loam Cagey gravelly loam Cagey silt loam Cagey silt loam-Norma silty clay loam complex (see Norma silty clay loam) | | | | | | | | | | | Moderate | Moderate |
| 0-15% | B: wetness shrink-swell | A | D: perme-ability, less than 0.05 in/hr. | A | A | D: cemented glacial till | D: cemented glacial till. Seasonal water table. | A: 0-3% slope | C: unstable soil & wet-ness. Soil moisture control. | A | | |
| 15-30% | C: slope & shrink-swell hazard | C: slope | | B: slope | B: slope | | | D: over 3% slope | | C: slope | | |
| Cagey gravelly sandy loam | | | | | | | | | | | Moderate | Moderate |
| 0-15% | B: wetness | A | D: perme-ability, less than 0.05 in/hr. | A | A | D: cemented glacial till | D: cemented glacial till. Seasonal water table. | | C: unstable soil & wet-ness. Soil moisture control. | A | | |
| 15-30% | C: slope | C: slope | | B: slope | B: slope | | | D: over 3% slope | | C: slope | | |

Table 14. Comparative suitability of soils for suburban uses, Puget Sound Area (con.)

| Soil Series and Type | Suitability of Soils for Uses Cited 1/ | | | | | | | | | | | Corrosive Effect of Soil on | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Homesite | | | Community | | | | | Other | | | | |
| | Buildings | Land-scaping | Septic Tanks | Parks | Golf Courses | Sanitary Land Fill | Ceme-teries | Sewage Lagoons | Indus-trial | Small Farms and Gardens | | Uncoated Steel | Concrete |
| Camas clay loam<br>Camas gravelly loam | D: flood hazard | A | D: flooding | B: seasonal flooding | B: seasonal flooding | D: flooding | D: flooding | D: flooding | D: flood hazard | B: flood hazard | | High<br>Low | Low<br>Low |
| Carbondale muck (McMurray) | D: wet; very low bearing strength | D: wet | D: water table | D: wet | D: wet | D: water table | D: water table | D: wet; unstable | C: unstable soils. Re-move soil & moisture control. | B: water table | | Very high | High |
| Carbondale muck, shallow | D: unsuitable; wet | D: wet | D: water table | D: wet | D: wet | D: water table | D: water table | D: unstable | C: remove muck & soil moisture control | C: water table & drainage | | Very high | High |
| Carlsborg gravelly loam<br>Carlsborg gravelly sandy loam | A | A | A | A | A | A | A | D: perme-ability, 5.0-10.0 in/hr. | A | B: soil texture | | Very low to low | Low |
| Carstairs gravelly loam | A | B: Soil, low moisture | A | A | A | A | A | D: perme-ability, 5.0-10.0 in/hr. | A | C: droughty | | Very low to low | High |
| Casey fine sandy loam<br>Casey loam<br>Casey silt loam | C: unstable wet | B: shallow soil; wet | D: perme-ability, 0.05-0.2 in/hr. | C: wet | C: wet | D: water table | D: water table | D: water table | B: wet soil, soil moisture control | C: wet, shallow soil | | Low to high | Moderate |

Table 14. Comparative suitability of soils for suburban uses, Puget Sound Area (con.)

| Soil Series and Type | Suitability of Soils for Uses Cited 1/ | | | | | | | | | | Corrosive Effect of Soil on | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Homesite | | | Community | | | | | Other | | | |
| | Buildings | Land-scaping | Septic Tanks | Parks | Golf Courses | Sanitary Land Fill | Ceme-teries | Sewage Lagoons | Indus-trial | Small Farms and Gardens | Uncoated Steel | Concrete |
| Cathcart loam<br>Cathcart gravelly loam<br>Cathcart gravelly silt loam<br>Cathcart fine sandy loam | | | | | | | | | | | Moderate | Moderate |
| 3-8% | C: soil | A | D: bedrock | A | A | D: bedrock | D: bedrock | D: slope & bedrock | A | B: slope | | |
| 8-15% | C: soil & slope | A | | A | B: slope | | | | B: slope | C: slope | | |
| 15-30% | C: soil & slope | A | | B: slope | D: slope | | | | D: slope | D: slope | | |
| over 30% | D | D: slope | | D: slope | D: slope | | | | D: slope | D: slope | | |
| Cathcart stony loam | | | | | | | | | | | Moderate | Moderate |
| 8-15% | C: soil | B: soil | D: bedrock | A | C: slope & soil | D: bedrock | D: bedrock & soil | D: slope & bedrock | B: slope | C: soil & slope | | |
| 15-30% | C: soil & slope | B: soil | | B: slope & soil | D: slope | | | | D: slope | D: slope & soil | | |
| over 30% | D: soil & slope | D: slope & soil | | D: slope & soil | D: slope | | | | D: slope | D: slope & soil | | |
| Chehalis loam<br>Chehalis silt loam<br>Chehalis silty clay loam<br>Chehalis silt loam, mottled | D: flooding | A | D: flooding | B: flooding | B: flooding | D: flooding | D: flooding | D: flooding | C: flood water control | A | Moderate | Moderate |
| Chimacum gravelly sandy loam | | | | | | | | | | | Very low | High |
| 3-8% | A | C: droughty | A | A | B: droughty | A | A | D: perme-ability, 5.0-10.0 in/hr. Contamina-tion hazard | A | C: droughty | | |
| 15-30% | C: slope | | C: slope | A | D: slope & droughty | D: slope | D: slope | | C: slope | D: slope & droughty | | |

Table 14. Comparative suitability of soils for suburban uses, Puget Sound Area (con.)

| Soil Series and Type | Suitability of Soils for Uses Cited 1/ | | | | | | | | | | Corrosive Effect of Soil on | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Homesite | | | Community | | | | | Other | | | |
| | Buildings | Land-scaping | Septic Tanks | Parks | Golf Courses | Sanitary Land Fill | Cemeteries | Sewage Lagoons | Indus-trial | Small Farms and Gardens | Uncoated Steel | Concrete |
| Chimacum gravelly loamy sand; Chimacum very gravelly loamy sand | | | | | | | | | | | Very low | High |
| 3-8% | B: droughty | C: droughty | A | A | B: droughty | A | A | D: perme-ability, 5.0-10.0 in/hr. Contamina-tion hazard | A | C: droughty | | |
| 15-30% | C: slope | | C: slope | A | D: droughty & slope | D: slope | D: slope | | C: slope | D: slope & droughty | | |
| Cinebar silt loam 0-3% | A | A | B: perme-ability, 0.2-0.8 in/hr. | A | A | A | A | A | A | A | Low | Moderate |
| Cispus pumicy sandy loam 0-3% | A | B: droughty | B: perme-ability, 0.2-0.8 in/hr. | A | B: droughty | A | A | A | A | B: droughty | Low | Low |
| Clackamas silty clay loam 0-3% | D: unstable soil; high shrink-swell; wet | C: shallow soil; wet | D: perme-ability, 0.05-0.2 in/hr. | D: wet soils | D: water table | D: water table | D: water table | D: water table; cracks when dry. | D: unstable soil; high shrink-swell. Soil moisture control. | B: shallow wet soil | Very high | Moderate |
| Clallam gravelly loam; Clallam loam | | | | | | | | | | | Moderate | Moderate |
| 3-8% | B: seasonal water table | A | D: perme-ability, less than 0.05 in/hr. | A | A | D: cemented glacial till & water table | D: cemented glacial till & water table | D: slope | B: soil moisture control | B: soil & wetness | | |

15-30% & over 30% continued on next page.

Table 14. **Comparative suitability of soils for suburban uses, Puget Sound Area (con.)**

| Soil Series and Type | Suitability of Soils for Uses Cited 1/ | | | | | | | | | | Corrosive Effect of Soil on | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Homesite | | | Community | | | | | Other | | | |
| | Buildings | Land-scaping | Septic Tanks | Parks | Golf Courses | Sanitary Land Fill | Ceme-teries | Sewage Lagoons | Indus-trial | Small Farms and Gardens | Uncoated Steel | Concrete |
| Clallam gravelly loam<br>Clallam loam | | | | | | | | | | | Moderate | Moderate |
| 15-30% | C: slope & water table | A | | A | C: slope | | | | D: slope | D: slope | | |
| over 30% | D: slope | D: slope | | D: slope | D: slope | | | | | | | |
| Clallam gravelly sandy loam | | | | | | | | | | | Moderate | Moderate |
| 3-8% | B: seasonal water table | A | D: perme-ability, less than 0.05 in/hr. | A | A | D: cemented glacial till & wa-ter table | D: cemented glacial till & wa-ter table | D: slope | B: soil moisture control | B: soil & wetness | | |
| 15-30% | C: slope & water table | A | | A | C: slope | | | | D: slope | D: slope | | |
| Clipper silty clay loam | D: wet | D: shallow soil & wet | D: water table | D: wet | D: wet | D: water table | D: water table | D: water table | D: wet | B: shallow soil & wet | High | Moderate |
| Cloquallum silt loam<br>Cloquallum loam<br>Cloquallum silt loam, shallow over till | | | | | | | | | | | High | Moderate |
| 3-8% | B: seasonal water table & shrink- | A | D: water table | B: seasonal wetness | B: seasonal wetness | D: seasonal water table | D: seasonal water table | D: slope | B: soil moisture control; moderate shrink-swell | B: soil & wetness | | |
| 8-15% | C: wetness slope & shrink-swell | A | | B: seasonal wetness | C: wetness & slope | | | | C: slope & soil moisture control | D: slope, soil & wetness | | |
| 15-30% | D: slope | A | | C: slope & wetness | C: slope | | | | D: slope | D: slope & soil | | |

Table 14. Comparative suitability of soils for suburban uses, Puget Sound Area (con.)

| Soil Series and Type | Suitability of Soils for Uses Cited 1/ | | | | | | | | | | Corrosive Effect of Soil on | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Homesite | | | Community | | | | | Other | | | |
| | Buildings | Land-scaping | Septic Tanks | Parks | Golf Courses | Sanitary Land Fill | Ceme-teries | Sewage Lagoons | Indus-trial | Small Farms and Gardens | Uncoated Steel | Concrete |
| Cloquallum silty clay loam | | | | | | | | | | | High | Moderate |
| 8-15% | C: shrink-swell, slope & wetness | A | D: water table | B: seasonal wetness | C: slope & wetness | D: seasonal wetness & slope | D: seasonal wetness | D: slope | C: slope & soil moisture control | C: slope, soil & wetness | | |
| Coastal beach | D | D: unstable | D: wet | A | D: unstable | D: unstable | D: unstable | D: wet | C: unstable | C: soil unstable | Moderate | Low to Moderate |
| Cokedale loam<br>Cokedale silt loam | D: flooding | A | D: periodic flooding | B: periodic flooding | B: periodic flooding | D: periodic flooding | D: periodic flooding | D: periodic flooding | C: control periodic flooding | A | Low to Moderate | Moderate |
| Cokedale silt loam<br>Cokedale sandy loam<br>Cokedale silt loam/Puyallup | D: flooding | A | D: periodic flooding | B: periodic flooding | B: periodic flooding | D: periodic flooding | D: periodic flooding | D: periodic flooding | D: periodic flooding | A | Moderate | Moderate |
| Cokedale silty clay loam<br>Cokedale silty clay loam/Puyallup | | | | | | | | | | | High | Moderate |
| Colvos fine sandy loam | | | | | | | | | | | Moderate | Low |
| 3-8% | B: soil | A | D: permeability, 0.05-0.2 in/hr. | A | A | D: cemented glacial till | D: cemented glacial till | D: piping hazard high | A | C: soil | | |
| 15-30% | C: slope | A | | | | | | | D: slope | D: slope & soil | | |
| over 30% | D: slope | D: slope | | D: slope | D: slope | | | | | | | |

Table 14. Comparative suitability of soils for suburban uses, Puget Sound Area (con.)

| Soil Series and Type | Suitability of Soils for Uses Cited 1/ | | | | | | | | | | Corrosive Effect of Soil on | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Homesite | | | Community | | | | | Other | | | |
| | Buildings | Land-scaping | Septic Tanks | Parks | Golf Courses | Sanitary Land Fill | Ceme-teries | Sewage Lagoons | Indus-trial | Small Farms and Gardens | Uncoated Steel | Concrete |
| Colvos fine sandy loam/Everett gravelly sandy loam complex (see Everett gravelly sandy loam for additional interpretations) Colvos fine sandy loam/Kitsap silt loam complex (see Kitsap silt loam for additional interpretations) | | | | | | | | | | | Moderate | Low |
| 3-8% | B: soil | A | D: perme-ability 0.05-0.2 in/hr. | A | A | D: cemented glacial till | D: cemented glacial till | D: piping hazard high | A | C: soil slope & soil | | |
| 15-30% | C: slope | A | | | | | | | D: slope | | | |
| over 30% | D: slope | D: slope | | D: slope | D: slope | | | | D: slope | | | |
| Corkindale loam | | | | | | | | | | | Low | High |
| 0-3% | A | A | A | B: droughty soil | A | A | A | D: perme-ability, 5.0-10.0 in/hr. Contamina-tion hazard | A | C: soil | | |
| 3-8% | A | A | A | B: droughty soil | B: slope & droughty soil | A | A | | A | C: soil | | |
| 8-15% | A | A | B: slope | B: droughty soil | B: slope & droughty soil | D: slope | B: slope | | B: slope | C: soil & slope | | |
| 15-30% | C: slope | A | D: slope | B: slope | D: slope | D: slope | D: slope | | D: slope | D: slope & soil | | |
| over 30% | D: slope | D: slope | D: slope | D: slope | D: slope | D: slope | D: slope | | D: slope | D: slope & soil | | |
| Coupeville loam Coupeville silt loam | | | | | | | | | | | Moderate to Very High | Moderate |
| 0-3% | D: soil shrink-swell & seasonal wetness | A | D: perme-ability, 0.05-0.2 in/hr. | A | A | D: dense soil in sub-stratum | D: dense soil in sub-stratum & seasonal wetness | C: berm; may crack when dry | C: soil shrink-swell, seasonal wetness; soil moisture control | A | | |

Table 14. Comparative suitability of soils for suburban uses, Puget Sound Area (con.)

| Soil Series and Type | Suitability of Soils for Uses Cited 1/ | | | | | | | | | | Corrosive Effect of Soil on | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Homesite | | | Community | | | | | Other | | | |
| | Buildings | Land-scaping | Septic Tanks | Parks | Golf Courses | Sanitary Land Fill | Ceme-teries | Sewage Lagoons | Indus-trial | Small Farms and Gardens | Uncoated Steel | Concrete |
| Coveland gravelly loam<br>Coveland gravelly silt loam | | | | | | | | | | | Moderate to High | Low |
| 0-3% | D: soil shrink-swell high; poorly drained | C: shallow soil, wet | D: perme-ability less than 0.05 in/hr. | D: poorly drained | D: poorly drained | D: poorly drained; dense soil | D: poorly drained | C: berm; may crack when dry<br>D: slope | C: soil unstable; high shrink-swell; soil moisture control | B: poorly drained | | |
| Coveland silt loam<br>0-3%<br>3-8% | D: soil shrink-swell high; poorly drained | C: shallow soil, wet | D: perme-ability, less than 0.05 in/hr. | D: poorly drained | D: poorly drained | D: poorly drained dense soil | D: poorly drained | | C: soil unstable; high shrink-swell; soil moisture control | B: poorly drained | Moderate to High | Low |
| Coveland loam<br>0-3%<br>3-8% | D: soil shrink-swell high; poorly drained | C: shallow soil, wet | D: perme-ability, less than 0.05 in/hr. | D: poorly drained | D: poorly drained | D: poorly drained dense soil | D: poorly drained | C: berm, may crack when dry.<br>D: slope | C: soil unstable; high shrink-swell; soil moisture control | B: poorly drained | Moderate to High | Low |
| Coveland stony silt loam | | | | | | | | | | | Moderate to High | Low |
| 8-15% | D: slope & high shrink-swell | D: slope & shallow soil | D: perme-ability, less than 0.05 in/hr. | D: slope & poorly drained | D: slope & poorly drained | D: poorly drained dense soil & slope | D: poorly drained | D: slope | C: soil unstable; high shrink-swell; soil moisture control & slope | D: slope, soil & poorly drained | | |

Table 14. Comparative suitability of soils for suburban uses, Puget Sound Area (con.)

| Soil Series and Type | Suitability of Soils for Uses Cited 1/ | | | | | | | | | | Corrosive Effect of Soil on | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Homesite | | | Community | | | | | Other | | | |
| | Buildings | Land-scaping | Septic Tanks | Parks | Golf Courses | Sanitary Land Fill | Ceme-teries | Sewage Lagoons | Indus-trial | Small Farms and Gardens | Uncoated Steel | Concrete |
| Crescent gravelly loam | | | | | | | | | | | Low | Moderate |
| 3-8% | A | C: droughty | A | C: droughty | A | D: subsoil rocky | D: subsoil rocky | D: perme-ability, 5.0-10.0 in/hr. | A | C: soil droughty | | |
| Custer sandy loam<br>Custer fine sandy loam<br>Custer silt loam | C: water table. May be "quick" | A | D: water table | B: seasonal wetness | B: seasonal wetness | D: water table | D: water table | D: water table | B: seasonal water table. May be "quick" & settle. Water control. | A | Moderate | High |
| Dabob very grav-elly sandy loam | | | | | | | | | | | Low | Moderate |
| 3-8% | A | B: shallow soil | D: cemented substrata | B: soil | B: soil | D: cemented substrata | D: cemented substrata | D: slope | A | D: soil | | |
| 15-30% | C: slope | | | D: slope | D: slope | | | | D: slope | | | |
| Delphi gravelly loam 8-15% | B: slope | A | D: cemented substrata | A | B: slope | D: cemented substrata | D: shallow cemented substrata | D: slope | C: slope | C: slope & soil | Moderate | Moderate |
| 15-30% | C: slope | A | | A | C: slope | | | | D: slope | D: slope | | |
| Dick loamy fine sand<br>Dick loamy sand<br>Dick loamy sand/ Chimacum gravelly loamy sand com-plex (see Chima-cum gravelly loamy sand) | | | | | | | | | | | Low | Moderate |
| 3-8% | B: soil texture | A | A | B: soil texture, unstable | B: soil texture, droughty | A | A | A: soil perme-ability, 5.0-10.0 in/hr. | A | B: soil texture, droughty | | |
| 8-15% | B: slope & soil texture | A | B: slope | C: slope & soil texture | C: slope & soil texture | B: slope | B: slope | | B: slope | C: slope & soil texture | | |

Table 14. Comparative suitability of soils for suburban uses, Puget Sound Area (con.)

| Soil Series and Type | Suitability of Soils for Uses Cited 1/ | | | | | | | | | | Corrosive Effect of Soil on | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Homesite | | | Community | | | | | Other | | | |
| | Buildings | Land-scaping | Septic Tanks | Parks | Golf Courses | Sanitary Land Fill | Ceme-teries | Sewage Lagoons | Indus-trial | Small Farms and Gardens | Uncoated Steel | Concrete |
| Discovery Bay gravelly sandy loam<br>Discovery Bay very gravelly sandy loam<br>Discovery Bay/Alderwood gravelly sandy loam (see Alderwood)<br>Discovery Bay/Hoodsport gravelly sandy loam complex (see Hoodsport)<br>Discovery Bay/Rock outcrop complex (see Rock outcrop) 15-30% | D: slope & shallow soil | D: slope & shallow soil | D: slope & soil | D: slope & rocky soil | D: slope & rocky soil | D: cemented conglomerate substrata | D: cemented substrata | D: slope | D: slope & soil | D: slope & soil | Low | Moderate |
| Dungeness loam<br>Dungeness silt loam 0-3% | D: flood hazard | A | D: flood hazard | A | A | D: flood hazard | D: flood hazard | D: flood hazard | D: flood hazard | A | Low | High |
| Dungeness fine sandy loam<br>Dungeness fine sandy loam, shallow | D: flood hazard | A | D: flood hazard | A | A | D: flood hazard | D: flood hazard | D: flood hazard | D: flood hazard | A | Low | High |
| Dupont muck | D: unstable low bearing strength & wet | D: wet | D: water table | D: unstable & wet | D: very wet | D: water table | D: water table | D: water table | D: unstable low bearing strength; water control | B: soil, wet | Very High | High |

Table 14. Comparative suitability of soils for suburban uses, Puget Sound Area (con.)

| Soil Series and Type | Suitability of Soils for Uses Cited 1/ | | | | | | | | | | Corrosive Effect of Soil on | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Homesite | | | Community | | | | | Other | | | |
| | Buildings | Land-scaping | Septic Tanks | Parks | Golf Courses | Sanitary Land Fill | Ceme-teries | Sewage Lagoons | Indus-trial | Small Farms and Gardens | Uncoated Steel | Concrete |
| Ebeys sandy loam 0-3% | A | A | C: may have seasonal water table | A | A | C: may have seasonal water table | C: may have seasonal water table | D: soil permeability, 5.0/10.0 in/hr. | B: soil moisture control | A | Low | Moderate |
| Edgewick fine sandy loam | D: flooding | C: flooding | D: flooding | B: flooding | B: flooding | D: flooding | D: flooding | D: flooding | D: flood hazard | C: flooding & soil | Low | Moderate |
| Edgewick silt loam | D: flooding | C: flooding | | B: flooding | B: flooding | D: flooding | D: flooding | | D: flood hazard | | | |
| Edgewick very fine sandy loam | D: flooding | C: flooding | | B: flooding | B: flooding | D: flooding | D: flooding | | D: flood hazard | | | |
| Edgewick sand | D: flooding | C: flooding | | B: flooding | D: flooding | D: flooding | D: flooding | | D: flood hazard | | | |
| Edmonds sandy loam<br>Edmonds silt loam<br>Edmonds loam<br>Edmonds/Tromp silt loam (see Tromp silt loam)<br>Edmonds fine sandy loam 0-3% | B: wet; may become "quick" | B: wet | D: water table | B: wet | C: wet | D: water table | D: water table | D: water table | B: wet; soil moisture control | B: water table & soil | High | Moderate |
| Eld loam<br>Eld gravelly loam<br>Eld silt loam<br>Eld silty clay loam | D: flooding | A | D: flooding | B: flooding | B: flooding | D: flooding | D: flooding | D: flooding | C: flood water control | A | Moderate | Moderate |
| Elwha loam 8-15% | D: soil, shrink-swell | A | D: slope & soil | A | B: slope | D: dense sandy clay 20-36". Wetness hazard. | C: soil shrink-swell very dangerous. Soil moisture control. | | C: slope & soil | D: soil permeability, 0.05-0.2 in/hr. | Moderate | Moderate |
| 15-30% | D. slope & soil shrink-swell | A | | A | D: slope | | | | | | | |

Table 14. Comparative suitability of soils for suburban uses, Puget Sound Area (con.)

| Soil Series and Type | Suitability of Soils for Uses Cited 1/ | | | | | | | | | | Corrosive Effect of Soil on | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Homesite | | | Community | | | | | Other | | | |
| | Buildings | Land-scaping | Septic Tanks | Parks | Golf Courses | Sanitary Land Fill | Ceme-teries | Sewage Lagoons | Indus-trial | Small Farms and Gardens | Uncoated Steel | Concrete |
| Enumclaw loam<br>Encumclaw fine sandy loam<br>Enumclaw gravelly sandy loam | | | | | | | | | | | High | Moderate |
| 0-3% | B: wetness & soil | C: wetness & soil depth | D: soil per-meability, 0.05-0.2 in/hr. | C: wetness | B: seasonal wetness | D: seasonal water table | D: seasonal water table | D: soil stability | C: wetness & shear strength. Soil moisture control. | | | |
| 3-8% | B: soil & wetness | | | | | | | | | B: soil & wetness | | |
| Everett gravelly sandy loam | | | | | | | | | | | Very Low | Moderate |
| 0-3% | A | A | A | A | A | A | A | D: perme-ability, 5.0-10.0 in/hr. | A | B: soil | | |
| 3-8% | A | A | A | A | A | A | A | D: slope | A | B: soil | | |
| 8-15% | B: slope | A | B: slope | B: slope | B: slope | C: slope | C: slope | D: slope | B: slope | B: slope & soil | | |
| 15-30% | C: slope | B: slope | C: slope | C: slope | C: slope | D: slope | D: slope | D: slope | C: slope | D: slope & soil | | |
| over 30% | D: slope | D: slope | D: slope | D: slope | D: slope | D: slope | D: slope | D: slope | D: slope | D: slope & soil | | |

Table 14. Comparative suitability of soils for suburban uses, Puget Sound Area (con.)

| Soil Series and Type | Suitability of Soils for Uses Cited 1/ | | | | | | | | | | Corrosive Effect of Soil on | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Homesite | | | Community | | | | | Other | | | |
| | Buildings | Land-scaping | Septic Tanks | Parks | Golf Courses | Sanitary Land Fill | Cemeteries | Sewage Lagoons | Industrial | Small Farms and Gardens | Uncoated Steel | Concrete |
| Everett gravelly loamy sand<br>Everett stony sandy loam<br>Everett stony loamy sand | | | | | | | | | | | Very Low | Moderate |
| 0-3% | C: soil | C: soil moisture | A | B: soil moisture | B: soil moisture | A | A | D: soil perme-ability, 5.0-10.0 in/hr. | A | C: soil moisture | | |
| 3-8% | C: soil | C: soil moisture | A | B: soil moisture | B: soil moisture | A | A | | A | C: soil moisture | | |
| 8-15% | C: slope & soil | C: soil moisture | B: slope | C: slope & soil moisture | C: slope & soil moisture | C: slope | C: slope | | B: slope | C: soil moisture | | |
| 15-30% | D: slope & soil | C: soil moisture | C: slope | C: soil moisture | D: slope | D: slope | D: slope | | D: slope | D: slope & soil moisture | | |
| over 30% | D: slope & soil | D: slope & soil moisture | D: slope | D: soil moisture | D: slope | D: slope | D: slope | | D: slope | D: slope & soil moisture | | |
| Everett gravelly loam | | | | | | | | | | | Very Low | Moderate |
| 0-3% | A | A | A | A | A | A | A | D: soil perme-ability, 5.0-10.0 in/hr. | A | B: soil | | |
| 3-8% | A | A | A | A | A | A | A | | A | B: soil | | |
| 8-15% | B: slope & soil | A | B: slope | B: slope & soil | B: slope & soil | A | B: slope | | B: slope | C: slope & soil | | |
| Everson silt loam<br>Everson fine sandy loam<br>Everson clay loam | D: soil shrink-swell & wet | C: soil depth 12-20"; wet | D: perme-ability, 0.05-0.2 in/hr.; & water table | D: wetness | D: wetness | D: water table | D: water table | D: piping hazard & water table | C: danger-ous soil shrink-swell; wet; soil moisture control | C: wet & shallow soil | Very High | High |
| Fidalgo rocky loam | | | | | | | | | | | Low | High |
| 8-15% | B: soil & bedrock | B: soil | D: bedrock | B: rocky soil | B: slope & rocky soil | D: bedrock | D: bedrock | D: bedrock | B: slope & soil | C: soil & slope | | |
| 15-30% | C: slope, soil & bedrock | B: slope & soil | | C: slope & soil | D. slope | | | | D: slope & soil | D: slope & soil | | |
| over 30% | D: slope, soil & rock outcrop | D: slope & soil | | D: slope & soil | D: slope | | | | D: slope & soil | D: slope & soil | | |

Table 14. Comparative suitability of soils for suburban uses, Puget Sound Area (con.)

| Soil Series and Type | Suitability of Soils for Uses Cited 1/ | | | | | | | | | | Corrosive Effect of Soil on | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Homesite | | | Community | | | | | Other | | | |
| | Buildings | Land-scaping | Septic Tanks | Parks | Golf Courses | Sanitary Land Fill | Ceme-teries | Sewage Lagoons | Indus-trial | Small Farms and Gardens | Uncoated Steel | Concrete |
| Fitch gravelly sandy loam | | | | | | | | | | | Very Low | Moderate |
| 0-3% | A | B: soil moisture | A | A | A | A | A | D: soil perme-ability, 5.0-10.0 in/hr. | A | B: soil moisture 5" | | |
| 3-8% | A | B: soil moisture | A | A | A | A | A | | A | B: soil moisture 5" | | |
| 8-15% | B: slope | B: soil moisture | B: slope | B: slope | B: slope | C: slope | C: slope | | B: slope | C: slope & soil | | |
| 15-30% | C: slope | C: slope & soil moisture | C: slope | C: slope | C: slope | D: slope | D: slope | | C: slope | D: slope & soil | | |
| Fresh water marsh | D: water | D: water | D: water | D: water | D: water | D: water | D: water | D: water | D: water | D: water | Very High | Very High |
| Giles loam<br>Giles silt loam<br>Giles silt loam, gravelly subsoil<br>Giles/Tromp silt loam complex (see Tromp silt loam) | | | | | | | | | | | Low | Moderate |
| 0-3% | A | A | A | A | A | A | A | B: high piping hazard | C: soil moisture control, shear strength | A | | |
| 3-8% | A | A | A | A | A | A | A | D: slope | C: shear strength | A | | |
| 8-15% | B: slope | A | B: slope | A | B: slope | B: slope | B: slope | D: slope | C: slope | B: slope | | |
| 15-30% | C: slope | B: slope | D: slope | B: slope | C: slope | D: slope | D: slope | D: slope | D: slope | D: slope | | |

Table 14. Comparative suitability of soils for suburban uses, Puget Sound Area (con.)

| Soil Series and Type | Suitability of Soils for Uses Cited 1/ | | | | | | | | | | Corrosive Effect of Soil on | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Homesite | | | Community | | | | | Other | | | |
| | Buildings | Land-scaping | Septic Tanks | Parks | Golf Courses | Sanitary Land Fill | Cemeteries | Sewage Lagoons | Indus-trial | Small Farms and Gardens | Uncoated Steel | Concrete |
| Giles fine sandy loam 0-3% | A | A | A | A | A | A | A | B: high piping hazard | C: soil moisture control, shear strength | A | Low | Moderate |
| 8-15% | B: slope & shear strength | A | B: slope | A | B: slope | B: slope | B: slope | D: slope | C: slope | B: slope | | |
| 15-30% | C: slope & shear strength | B: slope | D: slope | B: slope | C: slope | D: slope | D: slope | D: slope | D: slope | D: slope | | |
| Gilligan loam<br>Gilligan silt loam<br>Gilligan gravelly loam | A | A | A | A | A | A | A | D: very high piping hazard | C: low to very low shear strength, soil moisture control | A | Low | Moderate |
| Gravel pits | D | D | D | D | D | A | D | D | D | D | Low | Low |
| Greenwater sand 0-8% | B: soil | C: soil moisture | A | B: soil moisture | A | A | A | D: perme-ability, 5.0-10.0 in/hr. | B: shearing strength | D: droughty | Low | High |
| Greenwater loamy sand 0-3% | B: soil | | A | B: soil moisture | A | A | | D: perme-ability, 5.0-10.0 in/hr. | B: shearing strength | D: droughty | Low | High |
| 3-8% | | C: soil moisture | A | B: soil moisture | A | A | A | | B: shearing strength | | | |
| 8-15% | | | B: slope | C: soil moisture | A | A | | | C: slope & shearing strength | D: droughty | | |

Table 14. Comparative suitability of soils for suburban uses, Puget Sound Area (con.)

| Soil Series and Type | Suitability of Soils for Uses Cited 1/ | | | | | | | | | | Corrosive Effect of Soil on | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Homesite | | | Community | | | | | Other | | | |
| | Buildings | Land-scaping | Septic Tanks | Parks | Golf Courses | Sanitary Land Fill | Ceme-teries | Sewage Lagoons | Indus-trial | Small Farms and Gardens | Uncoated Steel | Concrete |
| Greenwater sandy loam 0-3% | B: soil | C: soil moisture | A | B: soil moisture | A | A | A | D: perme-ability, 5.0-10.0 in/hr. | B: shearing strength | D: droughty | Low | High |
| Greenwood (Orcas) peat | D: low bearing capacity | D: very wet | D: water table | D: very wet | D: very wet | D: water table | D: water table | D: water table, unstable material | D: low bearing capacity | D: very low fertility | Very High | Very High |
| Grove gravelly loam | | | | | | | | | | | Low | High |
| 0-3% | A | A | A | A | A | A | A | D: soil perme-ability, 5.0-10.0 in/hr. | A | C: low moisture | | |
| 8-15% | B: slope | A | B: slope | A | B: slope | A | A | | B: slope | C: slope & soil | | |
| Grove gravelly sandy loam | | | | | | | | | | | Low | High |
| 0-3% | A | A | A | A | A | A | A | D: soil perme-ability, 5.0-10.0 in/hr. | A | C: low moisture | | |
| 3-8% | A | A | A | A | A | A | A | | A | C: low moisture | | |
| 8-15% | B: slope | A | B: slope | A | B: slope | C: slope | A | | B: slope | C: low moisture | | |
| 15-30% | C: slope | B: slope | D: slope | B: slope | D: slope | D: slope | D: slope | | D: slope | D: slope & low moisture | | |
| over 30% | D: slope | D: slope | D: slope | D: slope | D: slope | D: slope | D: slope | | D: slope | D: slope & low moisture | | |
| Grove stony sandy loam | | | | | | | | | | | Low | High |
| 0-3% | B: soil | B: soil | B: soil | B: soil | C: soil | B: soil | C: soil | D: soil perme-ability, 5.0-10.0 in/hr. | A | D: soil | | |

Table 14. Comparative suitability of soils for suburban uses, Puget Sound Area (con.)

| Soil Series and Type | Suitability of Soils for Uses Cited 1/ | | | | | | | | | | Corrosive Effect of Soil on | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Homesite | | | Community | | | | | Other | | | |
| | Buildings | Land-scaping | Septic Tanks | Parks | Golf Courses | Sanitary Land Fill | Ceme-teries | Sewage Lagoons | Indus-trial | Small Farms and Gardens | Uncoated Steel | Concrete |
| Grove cobbly sandy loam | | | | | | | | | | | Low | High |
| Grove very grav-elly sandy loam | | | | | | | | | | | | |
| 0-3% | C: soil texture | B: soil texture | A | B: soil texture | B: soil | A | A | D: perme-ability, 5.0-10.0 in/hr. | A | C: low moisture | | |
| 3-8% | C: soil texture | B: soil texture | A | B: soil texture | B: soil | A | A | | A | C: low moisture | | |
| 8-15% | C: soil texture | B: soil texture | B: slope | B: soil texture | C: slope | C: slope | A | | B: slope | D: slope & low moisture | | |
| 15-30% | D: slope & soil | C: slope & soil | D | C: slope & soil | D: slope | D: slope | D: slope | | D: slope | D: slope & low moisture | | |
| over 30% | D: slope & soil | D: slope & soil texture | D | D: slope & soil | D: slope | D: slope | D: slope | | D: slope | D: slope & low moisture | | |
| Hale silt loam | | | | | | | | | | | Moderate | Moderate |
| Hale-Norma silt loam (see Norma silt loam) | | | | | | | | | | | | |
| 0-3% | B: soil | A | D: perme-ability, less than 0.05 in/hr. | A | A | D: cemented substrata | D: cemented substrata | B: piping hazard | A | A | | |
| 3-8% | B: soil | A | | A | A | | | D: slope | A | A | | |
| 15-30% | D: slope & soil | C: slope & soil | | A | D: slope | | | D: slope | D: slope | D: slope | | |
| Harstine gravelly sandy loam | | | | | | | | | | | Low | High |
| 8-15% | B: slope | A | D: perme-ability, 0.05-0.2 in/hr. | A | B: slope | C: slope | C: slope & soil | D: slope | B: slope | C: slope & soil | | |
| 15-30% | C: slope | B: slope | | A | D: slope | D: slope | D: slope & soil | | D: slope | D: slope | | |

Table 14. Comparative suitability of soils for suburban uses, Puget Sound Area (con.)

| Soil Series and Type | Suitability of Soils for Uses Cited 1/ | | | | | | | | | | Corrosive Effect of Soil on | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Homesite | | | Community | | | | | Other | | | |
| | Buildings | Land-scaping | Septic Tanks | Parks | Golf Courses | Sanitary Land Fill | Ceme-teries | Sewage Lagoons | Indus-trial | Small Farms and Gardens | Uncoated Steel | Concrete |
| Heisler gravelly loam<br>Heisler shaly loam | | | | | | | | | | | Low | Low |
| 3-8% | C: soil, low shear-ing strength | A | D: bedrock 48-60" | A | A | D: bedrock 48-60" | D: bedrock 48-60" | D: slope & piping hazard | A | B: slope | | |
| 8-15% | C:soil, low shearing strength | A | | B: slope | B: slope | | | | B: slope | C: slope | | |
| 15-30% | D: slope & low shearing strength | B: slope | | C: slope | D: slope | | | | D: slope | D: slope | | |
| Heisler stony loam<br>15-30% | D: slope | B: slope | D: bedrock 48-60" | C: slope | D: slope | D: bedrock 48-60" | D: bedrock 48-60" | D: slope | D: slope | D: slope | Low | Low |
| over 30% | | D: slope | | D: slope | | | | | | | | |
| Hemmi silt loam | | | | | | | | | | | High | Moderate |
| 0-3% | D: high shrink-swell & water table | D: wet, shallow soil | D: water table | D: wet | D: wet | D: water table | D: water table | D: water table | C: soil moisture control; shrink-swell haz-ard & wa-ter table | C: wetness | | |
| Hoodsport gravelly sandy loam<br>Hoodsport stony sandy loam<br>Hoodsport very gravelly sandy loam | | | | | | | | | | | Low | High |
| 0-3% | C: soil | B: soil depth | D: cemented substrata | A | B: droughty soil | C: cemented substrata | D: cemented substrata at about 20" | D: high piping hazard | B: soil shearing strength | C: soil depth | | |
| 8-15% | C: soil & slope | B: soil depth | | B: soil & slope | C: soil & slope | | | | C: soil & slope | C: soil & slope | | |
| 15-30% | D: slope | C: soil & slope | | C: soil & slope | D: slope | | | | D: slope | D: slope | | |
| over 30% | D: slope | D: slope | | D: slope | D: slope | | | | D: slope | D: slope | | |

Table 14. Comparative suitability of soils for suburban uses, Puget Sound Area (con.)

| Soil Series and Type | Suitability of Soils for Uses Cited 1/ | | | | | | | | | | Corrosive Effect of Soil on | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Homesite | | | Community | | | | | Other | | | |
| | Buildings | Land-scaping | Septic Tanks | Parks | Golf Courses | Sanitary Land Fill | Ceme-teries | Sewage Lagoons | Indus-trial | Small Farms and Gardens | Uncoated Steel | Concrete |
| Hovde gravelly sandy loam<br>Hovde loamy sand<br>Hovde silty clay loam<br>Hovde sand<br>Hovde loam | D:<br>very wet | D:<br>very wet & salty | D:<br>water table | D:<br>very wet; salt flats | D:<br>very wet | D:<br>water table | D:<br>water table | D:<br>high water table; unstable material | D:<br>very wet; affected by tides | D:<br>very wet & salty | Very Low | Moderate |
| Hoypus coarse sandy loam | | | | | | | | | | | Very Low | Moderate |
| 0-3% | C: soil | C: droughty soil | A | C: soil droughty & unstable | C: soil droughty & unstable | A | A | D: perme-ability, 5.0-10.0 in/hr. | A | C: droughty soil | | |
| 8-15% | C: soil & slope | C: soil | B: slope | D: soil & slope | D: soil & slope | B: slope | B: slope | | B: slope | C: soil & slope | | |
| 15-30% | D: soil & slope | C: soil | D: slope | D: soil & slope | D: soil & slope | D: slope | D: slope | | D: slope | D: soil & slope | | |
| Hoypus gravelly loamy sand | | | | | | | | | | | Very low | Moderate |
| 0-3% | C: soil | C: droughty soil | A | C: soil droughty & unstable | C: soil droughty & unstable | A | A | D: perme-ability, 5.0-10.0 in/hr. | A | C: droughty soil | | |
| 3-8% | C: soil | C: soil | A | C: soil | C: soil | A | A | | A | C: droughty soil | | |
| 8-15% | C: soil & slope | C: soil | B: slope | D: soil & slope | D: soil & slope | B: slope | B: slope | | B: slope | C: soil & slope | | |
| 15-30% | D: soil & slope | C: soil | D: slope | D: soil & slope | D: soil & slope | D: slope | D: slope | | D: slope | D: soil & slope | | |
| Indianola fine sandy loam<br>Indianola sandy loam<br>Indianola sandy loam/Roche loam complex (see Roche loam) | | | | | | | | | | | Very Low | High |
| 0-3% | B: soil | B:) soil | A | A | A | A | A | D: perme-ability, 5.0-10.0 in/hr. | A | B:) soil | | |
| 3-8% | B: soil | B:)moisture | A | A | A | A | A | | A | B:)droughty | | |
| 8-15% | B: slope & soil | B:) | B: slope | B: slope & soil | B: slope | B: slope | C: slope | | B: slope | C: slope & soil | | |
| 15-30% | C: slope & soil | C: slope & soil moisture | D: slope | C: slope & soil | D: slope | D: slope | D: slope | | D: slope | D: slope | | |

Table 14. Comparative suitability of soils for suburban uses, Puget Sound Area (con.)

| Soil Series and Type | Suitability of Soils for Uses Cited 1/ | | | | | | | | | | Corrosive Effect of Soil on | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Homesite | | | Community | | | | | Other | | | |
| | Buildings | Land-scaping | Septic Tanks | Parks | Golf Courses | Sanitary Land Fill | Ceme-teries | Sewage Lagoons | Indus-trial | Small Farms and Gardens | Uncoated Steel | Concrete |
| Indianola loam, Indianola silt loam 3-8% | B: soil moisture | B: soil moisture | A | A | A | A | A | D: perme-ability, 5.0-10.0 in/hr. | A | B: soil droughty | Low | High |
| Indianola loamy fine sand 8-15% | B: slope & soil | B: soil moisture | B: slope | B: slope & soil | B: slope | B: slope | C: slope | D: perme-ability, 5.0-10.0 in/hr. | B: slope | D: slope & soil | Very Low | High |
| Issaquah silt loam | D: wet, floods; moderate to high shrink-swell | B: wet, shallow soil | D: flooding & water table | B: wet, shallow soil | C: wet | D: water table & *flooding* | D: water table & *flooding* | D: flooding & water table | D: soil moisture control; very low shearing strength: flooding | C: wet, shallow soil | Very High | Low |
| Juno gravelly sandy loam, Juno loamy sand, Juno sandy loam, Juno loam | D: frequent flooding | C: flooding | D: flooding | B: flooding | C: flooding & droughty soil | D: flooding | D: flooding | D: flooding | D: flood hazard | D: flooding & droughty soil | Very Low | High |
| Kapowsin gravelly clay loam | | | | | | | | | | | High | Moderate |
| Kapowsin gravelly sandy loam | | | | | | | | | | | Very High | Low |
| 3-8% | B: wetness & soil | B: wetness & soil depth | D: perme-ability, 0.05-0.2 in/hr. | B: wetness | B: seasonal wetness | D: cemented substrata & water table | D: water table & cemented substrata | D: slope | B: soil moisture control | B: wetness & soil | | |
| 15-30% | C: slope & soil | B: wetness & soil depth | | B: slope & wetness | D: slope | | | | D: slope, shearing strength & soil moisture control | D: slope | | |

Table 14. Comparative suitability of soils for suburban uses, Puget Sound Area (con.)

| Soil Series and Type | Suitability of Soils for Uses Cited 1/ | | | | | | | | | | Corrosive Effect of Soil on | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Homesite | | | Community | | | | | Other | | | |
| | Buildings | Land-scaping | Septic Tanks | Parks | Golf Courses | Sanitary Land Fill | Ceme-teries | Sewage Lagoons | Indus-trial | Small Farms and Gardens | Uncoated Steel | Concrete |
| Kapowsin gravelly loam | | | | | | | | | | | High | Moderate |
| 0-3% | B: )wetness, )shallow )soil & )shrink- )swell | B: )wetness )& soil )depth ) | D: perme-ability, 0.05-0.2 in/hr. | C: seasonal wetness | C: seasonal wetness | D: cemented substrata & water table | D: water table & cemented substrata | C: severe piping hazard | B: soil moisture control | B: )wetness )& )shallow )soil ) | | |
| 3-8 | B: ) ) | B: ) ) ) | | B: seasonal wetness | C: seasonal wetness | | | D: slope | B: soil moisture control | B: ) | | |
| 8-15% | B: ) | B: ) ) ) ) ) ) | | B: seasonal wetness | C: slope & wetness | | | D: slope | C: soil moisture control, slope, shearing strength | C: slope, wetness & shallow soil | | |
| 15-30% | C: slope, shallow soil & shrink-swell | B: ) | | C: slope | D: slope | | | D: slope | D: slope & shearing strength | D: slope | | |
| Keystone fine sandy loam | | | | | | | | | | | Very Low | Moderate |
| 0-3% | A | B: droughty | A | A | A | A | A | D: perme-ability, 5.0-10.0 in/hr. | A | C: soil, low pro-ductivity | | |
| Keystone loamy sand 0-3% | B | B: droughty | A | A | A | A | A | D: perme-ability, 5.0-10.0 in/hr. | A | D: soil, low mois-ture & low produc-tivity | Very Low | Moderate |
| 8-15% | B | B: droughty | A | A | B: slope | B: slope | C: slope | | B: slope | | | |
| 15-30% | C: slope | B: droughty | D: slope | B) slope & | D: slope | D: slope | D: slope | | D: slope | | | |
| over 30% | D: slope | D: slope | D: slope | C) soil | D: slope | D: slope | D: slope | | D: slope | | | |
| Kickerville silt loam | | | | | | | | | | | Moderate | Low |
| 3-8% | A | A | B: cemented | A | A | B: cemented | A | D: slope & perme-ability, 5.0-10.0 in/hr. | A | A | | |
| 8-15% | B: slope | A | B: substrata | A | B: slope | B: substrata | B: slope | | B: slope | B: slope | | |
| 15-30% | C: slope | B: slope | D: at about | B: slope | D: slope | D: at about | D: slope | | D: slope | D: slope | | |
| over 30% | D: slope | D: slope | D: 10' slope | C: slope | D: slope | D: 10' slope | D: slope | | D: slope | D: slope | | |

Table 14. Comparative suitability of soils for suburban uses, Puget Sound Area (con.)

| Soil Series and Type | Suitability of Soils for Uses Cited 1/ | | | | | | | | | | Corrosive Effect of Soil on | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Homesite | | | Community | | | | | Other | | | |
| | Buildings | Land-scaping | Septic Tanks | Parks | Golf Courses | Sanitary Land Fill | Ceme-teries | Sewage Lagoons | Indus-trial | Small Farms and Gardens | Uncoated Steel | Concrete |
| Kitsap silt loam<br>Kitsap loam<br>Kitsap silty clay loam<br>Kitsap gravelly loam<br>Kitsap loam/ Indianola fine sandy loam com-plex (see Indian-ola fine sandy loam) | | | | | | | | | | | Moderate | High |
| 0-3% | B: )wetness<br>)& soil<br>)expan-<br>)sion | A | D: perme-ability, 0.05-0.2 in/hr. | A | B: seasonal wetness | D: seasonal water table | D: water table | D: high piping hazard & slope | C: )soil<br>)moisture<br>)control,<br>)very low | B: wetness | | |
| 3-8% | B: )danger-<br>)ous | A | | A | B: seasonal wetness | | | | C: )shearing<br>)strength | C: slope & wetness | | |
| 8-15% | D: )soil ex-<br>)pansion<br>)danger- | A | | A | B: slope & wetness | | | | D: )very low<br>)shearing<br>)strength | C: slope & wetness | | |
| 15-30% | D: )ous,very<br>)low<br>)shearing | B: slope | | B: slope | D: slope | | | | D: )& dan-<br>)gerous<br>)slide | D: slope | | |
| over 30% | D: )strength<br>)Danger-<br>)ous<br>)slide<br>)hazard | D: slope | | C: slope | D: slope | | | | D: )hazard | D: slope | | |
| Klaber silty clay loam | | | | | | | | | | | Very High | Very High |
| 0-3% | D: wet; very dangerous soil ex-pansion | C: wet | D: water table | D: wet | D: wet | D: water table | D: water table | D: high piping hazard; dense silty clay, mod-erate depth | D: very low shearing strength; dangerous expansion; soil moisture control | C: wetness | | |

Table 14. Comparative suitability of soils for suburban uses, Puget Sound Area (con.)

| Soil Series and Type | Suitability of Soils for Uses Cited 1/ | | | | | | | | | | Corrosive Effect of Soil on | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Homesite | | | Community | | | | | Other | | | |
| | Buildings | Landscaping | Septic Tanks | Parks | Golf Courses | Sanitary Land Fill | Cemeteries | Sewage Lagoons | Industrial | Small Farms and Gardens | Uncoated Steel | Concrete |
| Klaus gravelly loam<br>Klaus gravelly sandy loam<br>Klaus sandy loam | | | | | | | | | | | Very Low | High |
| 0-3% | B: soil | B: )low<br>)soil | A | A | A | A | A | D: permeability, 5.0-10.0 in/hr. | A | C: )low<br>)soil | | |
| 3-8% | B: soil | B: )moisture<br>) | A | A | A | A | A | | A | C: )moisture | | |
| 8-15% | C: slope & soil | B: ) | B: slope | B: slope | B: slope | B: slope | B: slope | | B: slope | C: slope & soil moisture | | |
| 15-30% | C: slope & soil | C: slope & soil | D: slope | C: slope | D: slope | D: slope | D: slope | | D: slope | D: slope | | |
| Kline gravelly loam<br>Kline loam<br>Kline silt loam<br>Kline sandy loam | D: flood hazard | B: flood hazard | D: flood hazard | B: flood hazard | B: flood hazard | D: flood hazard | D: flood hazard | D: flood hazard & permeability | D: flood hazard | A | Low | Moderate |
| Koch gravelly loam<br>Koch gravelly sandy loam<br>Koch silt loam | D: flooding | C: flooding & wetness | D: flooding | B: periodic flooding & wetness | C: periodic flooding & wetness | D: flooding | D: flood hazard | D: flooding | C: flood water control | C: wetness, flooding & shallow soil | High | High |
| Kopiah loam<br>Kopiah silt loam<br>Kopiah silty clay loam | D: shrink-swell very dangerous; shearing strength low. | B: wetness | D: water table & permeability, less than 0.05 in/hr. | C: wetness | C: wetness | D: water table | D: water table | D: water table | C: soil moisture control. Shrink-swell very dangerous. Shearing strength low. | B: wetness & shallow soil | High | High |

Table 14. Comparative suitability of soils for suburban uses, Puget Sound Area (con.)

| Soil Series and Type | Suitability of Soils for Uses Cited 1/ | | | | | | | | | | Corrosive Effect of Soil on | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Homesite | | | Community | | | | | Other | | | |
| | Buildings | Land-scaping | Septic Tanks | Parks | Golf Courses | Sanitary Land Fill | Ceme-teries | Sewage Lagoons | Indus-trial | Small Farms and Gardens | Uncoated Steel | Concrete |
| Labounty silt loam<br>Labounty silt loam/McKenna silty clay loam complex (see McKenna silty clay loam) | | | | | | | | | | | High | Low |
| 0-3% | D: shrink-swell dan-gerous; wet | C: wet, shallow soil | D: water table & per-meability | B: wet | C: wetness | D: water table | D: water table | C: soil stability | C: soil moisture control; shearing strength & shrink-swell dangerous | B: wetness | | |
| 3-8% | | | | B: wet | C: wetness | | | D: slope | | B: wetness & slope | | |
| 8-15% | D: slope | | | C: slope & wetness | C: slope & wetness | | | | | C: slope & wetness | | |
| 15-30% | D: slope | | | D: slope & wetness | D: slope | | | | | D: slope | | |
| Lummi silty clay loam<br>Lummi silt loam<br>Lummi fine sandy loam | D: flooding | C: flooding & wet | D: flooding | D: flooding & wet | D: flooding & wet | D: flooding | D: flooding | D: flooding | C: flood & water con-trol; low shearing strength. | B: wetness & flooding | Very High | High |
| Lynden loam<br>Lynden gravelly loam<br>Lynden gravelly sandy loam<br>Lynden loamy sand<br>Lynden sandy loam | | | | | | | | | | | Low | Low |
| 0-3% | B: soil | B: soil droughty | A | A | A | A | A | D: perme-ability; 5.0-10.0 in/hr. | A | B: soil droughty | | |
| 3-8% | B: soil | B: soil droughty | A | A | A | A | A | | A | B: soil droughty | | |
| 8-15% | C: slope & soil | B: soil droughty | B: slope | B: slope | B: slope | B: slope | B: slope | | B: slope | C: slope & soil | | |
| 15-30% | D: slope & soil | C: slope & soil | D: slope | C: slope | D: slope | D: slope | D: slope | | B: slope | D: slope | | |

Table 14. Comparative suitability of soils for suburban uses, Puget Sound Area (con.)

| Soil Series and Type | Suitability of Soils for Uses Cited 1/ | | | | | | | | | | Corrosive Effect of Soil on | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Homesite | | | Community | | | | | Other | | | |
| | Buildings | Land-scaping | Septic Tanks | Parks | Golf Courses | Sanitary Land Fill | Cemeteries | Sewage Lagoons | Indus-trial | Small Farms and Gardens | Uncoated Steel | Concrete |
| Lystair sandy loam<br>Lystair fine sandy loam<br>Lystair loamy sand | | | | | | | | | | | Low | High |
| 0-3% | B: soil | B: soil droughty | A | A | A | A | A | D: perme-ability, 5.0-10.0 in/hr. | A | B: soil droughty | | |
| 3-8% | B: soil | B: soil droughty | A | A | A | A | A | | A | B: soil droughty | | |
| 8-15% | C: slope & soil | B: soil droughty | B: slope | B: slope | B: slope | B: slope | B: slope | | B: slope | C: slope & soil | | |
| 15-30% | D: slope & soil | C: slope & soil | D: slope | C: slope | D: slope | D: slope | D: slope | | B: slope | D: slope | | |
| Marblemount stony loam 15-30% | D: soil & slope | C: soil & slope | D: bedrock | C: slope | D: slope | D: bedrock | D: bedrock & slope | D: slope | D: slope | D: slope & soil | Low | Moderate |
| Maytown silt loam<br>Maytown fine sandy loam | D: flooding | C: flooding | D: flooding | B: flooding | B: flooding | D: flooding | D: flooding | D: flooding | C: flood water control | B: flood hazard | High | Moderate |
| McKenna gravelly loam<br>McKenna silty clay loam<br>McKenna gravelly loam<br>McKenna loam | D: wet & high shrink-swell | C: wet, shallow soil | D: water table | D: wet | D: wet | D: water table & dense clay glacial till | D: water table & dense clay | D: wet & piping hazard | C: water control; low shearing strength & dangerous shrink-swell | C: wet, shallow soil | High | Low |
| McMurray (Rifle) peat<br>McMurray (Carbon-dale) muck<br>Mukilteo peat<br>Semiahmoo muck<br>McMurray peat, shallow/Mukilteo peat | D: low bearing strength, wet | D: wet | D: water table | D: wet | D: wet | D: water table | D: water table | D: water table | C: water control &/or remove peat. Low bearing strength. | B: wet, water table | Very High | High |

Table 14. Comparative suitability of soils for suburban uses, Puget Sound Area (con.)

| Soil Series and Type | Suitability of Soils for Uses Cited 1/ | | | | | | | | | | Corrosive Effect of Soil on | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Homesite | | | Community | | | | | Other | | | |
| | Buildings | Land-scaping | Septic Tanks | Parks | Golf Courses | Sanitary Land Fill | Cemeteries | Sewage Lagoons | Industrial | Small Farms and Gardens | Uncoated Steel | Concrete |
| Rifle (McMurray) peat/Bellingham silty clay loam complex (see Bellingham silty clay loam) McMurray (Rifle) peat, shallow McMurray (Carbondale) muck, shallow Mukilteo peat, shallow Semiahmoo muck, shallow | D: low bearing strength, wet | D: wet | D: water table | D: wet | D: wet | D: water table | D: water table | D: water table | C: water control and/or remove peat. Low bearing strength. | B: wet, water table | Very High | High |
| Melbourne loam | | | | | | | | | | | High | High |
| 0-3% | C: soil shrink-swell dangerous | B: soil shallow | D: bedrock | A | A | D: bedrock | D: bedrock | C: soil stability | B: water control; shrink-swell dangerous | B: soil | | |
| 3-8% | C: as above | B: soil shallow | | A | A | | | D: slope | B: as above | B: soil | | |
| 8-15% | C: as above | B: soil shallow | | B: slope | B: slope | | | D: slope | B: slope, & as above | C: slope & soil | | |
| Melbourne silty clay loam | | | | | | | | | | | High | High |
| 8-15% | C: slope & soil | B: soil | | B: slope | B: slope | D: bedrock | D: bedrock | D: slope | B: slope & water control; shrink-swell dangerous | C: slope & soil | | |
| 15-30% | D: slope & soil | D: slope | | D: slope | D: slope | | | D: slope | D: as above | D: slope | | |
| over 30% | D: slope & soil | D: slope | | D: slope | D: slope | | | D: slope | D: as above | D: slope | | |

Table 14. Comparative suitability of soils for suburban uses, Puget Sound Area (con.)

| Soil Series and Type | Suitability of Soils for Uses Cited 1/ | | | | | | | | | | Corrosive Effect of Soil on | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Homesite | | | Community | | | | | Other | | | |
| | Buildings | Land-scaping | Septic Tanks | Parks | Golf Courses | Sanitary Land Fill | Cemeteries | Sewage Lagoons | Industrial | Small Farms and Gardens | Uncoated Steel | Concrete |
| Melbourne stony loam 15-30% | D: slope & soil | D: slope | | D: slope | D: slope | D: bedrock | D: bedrock | D: slope | D: as above | D: slope | High | High |
| National pumicy loam; National pumicy sandy loam | | | | | | | | | | | Low to High | High |
| 3-8% | A | B: soil moisture | C: permeability, 0.2-0.8 in/hr. | A | A | B: soil | A | D: slope | B: soil stability | B: soil & climate | | |
| Neptune sandy loam; Neptune gravelly sandy loam | D: flood hazard | B: flood hazard | D: flood hazard | B: droughty soil | B: droughty soil | D: flood hazard | D: flood hazard | D: flood hazard | C: flood water control | C: fertility & flood hazard | Very Low | Low |
| Nesika loam; Nesika soils, undifferentiated | | | | | | | | | | | Low | Low |
| 0-3% | C: flood hazard | A | C: flood hazard | A | A | B: flood hazard | B: flood hazard | D: very high piping hazard | B: water control | A | | |
| 3-8% | C: flood hazard | A | C: flood hazard | A | A | B: flood hazard | B: flood hazard | D: slope | | A | | |
| Newberg loam | D: flood hazard | B: flood hazard | D: flood hazard | B: flood hazard | B: flood hazard | D: flood hazard | D: flood hazard | D: flood hazard | C: flood water control | A | Very Low to Low | Moderate |
| Newberg silt loam | | | | | | | | | | | Low | Moderate |
| Newberg loamy sand; Newberg loamy fine sand; Newberg sandy loam; Newberg fine sandy loam | D: flood hazard | B: flood hazard | D: flood hazard | B: flood hazard | B: flood hazard | D: flood hazard | D: flood hazard | D: flood hazard | C: flood water control | A | Very Low to Low | Moderate |

Table 14. Comparative suitability of soils for suburban uses, Puget Sound Area (con.)

| Soil Series and Type | Suitability of Soils for Uses Cited 1/ | | | | | | | | | | Corrosive Effect of Soil on | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Homesite | | | Community | | | | | Other | | | |
| | Buildings | Land-scaping | Septic Tanks | Parks | Golf Courses | Sanitary Land Fill | Ceme-teries | Sewage Lagoons | Indus-trial | Small Farms and Gardens | Uncoated Steel | Concrete |
| Nisqually sand<br>Nisqually loamy sand 3-8% | B: soil | C: droughty | A | A | A | A | A | D: slope & soil | A | B: soil droughty | Low | Moderate |
| 8-15% | B: slope & soil | C: slope & droughty | B: slope | B: slope & soil | B: slope | B: slope | C: slope | | B: slope | C: droughty & slope | | |
| Nookachamps silty clay loam<br>Nookachamps silt loam | D: flood hazard | C: flood hazard & wetness | D: flood hazard & soil perme-ability | D: flood hazard & wetness | D: flood hazard & wetness | D: flood | D: flood hazard | D: flood hazard | C: flood & water control; very low shearing strength when wet | B: flood hazard | High | Low |
| Nooksack silt loam<br>Nooksack fine sandy loam | D: flood hazard | B: flood hazard | D: flood hazard & soil perme-ability | B: flood hazard | B: flood hazard | D: flood hazard | D: flood hazard | D: flood hazard | D: flood & water control; very low shearing strength when wet | B: flood hazard | Moderate | Moderate |
| Nordby loam 3-8% | B: soil, shearing strength | A | A | A | A | A | A | D: slope | B: water control; shearing strength low when wet | B: soil moisture | Moderate | High |
| 8-15% | B: slope & soil | A | B: slope | A | B: slope | B: slope | B: slope | | B: slope & soil | C: slope & soil | | |

Table 14. Comparative suitability of soils for suburban uses, Puget Sound Area (con.)

| Soil Series and Type | Suitability of Soils for Uses Cited 1/ | | | | | | | | | | Corrosive Effect of Soil on | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Homesite | | | Community | | | | | Other | | | |
| | Buildings | Land-scaping | Septic Tanks | Parks | Golf Courses | Sanitary Land Fill | Cemeteries | Sewage Lagoons | Indus-trial | Small Farms and Gardens | Uncoated Steel | Concrete |
| Norma loam<br>Norma fine sandy loam<br>Norma clay loam<br>Norma silty clay loam<br>Norma silt loam<br>Norma sandy loam<br>Norma silty clay<br>Norma/Cagey complex<br>Norma/Hale complex (see Cagey & Hale soils) | D: wet; shrink-swell hazard | C: wet; shallow soil | D: water table | D: slow drainage | B: wet; slow drainage | D: water table | D: water table | D: water table & soil drainage | C: water control; low shearing strength when wet, & dangerous shrink-swell hazard | B: wetness and soil depth | Very Low | Low |
| Nuby silt loam | D: flood hazard | B: flood hazard | D: flood hazard | B: flood hazard | B: flood hazard | D: flood hazard | D: flood hazard | D: flood hazard | D: flood & water control | B: flood hazard | Low | High |
| Olete very gravelly silt loam<br>Olete complex | D: slope & shallow, rocky soil | D: slope & shallow, rocky soil | D: shallow to bedrock | D: slope & shallow, rocky soil | D: slope | D: shallow rocky soil | D: shallow rocky soil | D: slope | D: slope | D: slope & shallow, rocky soil | Low | Low |
| Olympic silty clay loam<br>Olympic stony clay loam | | | | | | | | | | | Moderate | High |
| 8-15% | B: shrink-swell & very low shearing strength | A | D: bedrock 12-48" | A | C: slope | D: bedrock 12-48" | D: bedrock 12-48" | D: slope | C: moisture control & slope | C: slope | | |
| 15-30% | C: slope & soil | B: slope | D: slope & soil | B: slope | D: slope | D: bedrock 12-48" | D: slope & soil | | D: slope | D: slope | | |
| over 30% | D: slope & soil | C: slope | D: slope & soil | C: slope | D: slope | D: bedrock 12-48" | D: slope & soil | | D: slope | D: slope | | |

Table 14. Comparative suitability of soils for suburban uses, Puget Sound Area (con.)

| Soil Series and Type | Suitability of Soils for Uses Cited 1/ | | | | | | | | | | Corrosive Effect of Soil on | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Homesite | | | Community | | | | | Other | | | |
| | Buildings | Land-scaping | Septic Tanks | Parks | Golf Courses | Sanitary Land Fill | Ceme-teries | Sewage Lagoons | Indus-trial | Small Farms and Gardens | Uncoated Steel | Concrete |
| Orcas (Greenwood) peat | D: wet; low bearing strength | D: wet & low fertility soil | D: water table | D: very wet | D: very wet | D: water table | D: water table | D: water table | D: wet & very low bearing strength | D: very low fertility & very wet | Very High | Very High |
| Orcas peat, shallow/gravel | D: wet; water control | D: soil & wetness | D: water table | D: wet | D: wet | D: water table | D: water table | D: water table | C: water control | D: soil & wetness | Very High | Very High |
| Orting gravelly sandy loam<br>Orting loam<br>Orting sandy loam<br>Orting stony sandy loam | B: soil & moisture control | A | D: soil permeability, 0.05-0.2 in/hr. | A | A | C: compact substratum | C: soil, compact, cobbly & stony | B: soil piping hazard | B: moisture control | A | High | Moderate |
| Oso loam 3-8% | B: soil & moisture control | A | D: soil perme-ability | A | A | D: soil bedrock 3'-6' | C: bedrock 3'-6' | D: slope | B: soil moisture control | B: soil | High | High |
| 8-15% | B: slope & soil | A | | A | A | | | | C: slope & soil | C: slope & soil | | |
| 15-30% | C: slope | B: slope | | B: slope | B: slope | | | | D: slope | D: slope | | |
| over 30% | D: slope | C: slope | | C: slope | D: slope | | | | D: slope | D: slope | | |
| Pickett/Rock outcrop complex | | | | | | | | | | | Low | Low |
| 15-30% | C: slope & soil | B: soil | D: bedrock 3'-6' | B: soil & slope | D: slope | D: bedrock 3'-6' | D: bedrock 3'-6' | D: slope | C: slope & water control | D: slope & soil | | |
| over 30% | D: slope | D: soil & slope | | C: slope & soil | D: slope | | | | D: slope | D: slope & soil | | |

Table 14. Comparative suitability of soils for suburban uses, Puget Sound Area (con.)

| Soil Series and Type | Suitability of Soils for Uses Cited 1/ | | | | | | | | | | Corrosive Effect of Soil on | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Homesite | | | Community | | | | | Other | | | |
| | Buildings | Land-scaping | Septic Tanks | Parks | Golf Courses | Sanitary Land Fill | Ceme-teries | Sewage Lagoons | Indus-trial | Small Farms and Gardens | Uncoated Steel | Concrete |
| Pilchuck sand<br>Pilchuck fine sand<br>Pilchuck loamy fine sand<br>Pilchuck loamy sand<br>Pilchuck gravelly sand<br>Pilchuck gravelly loamy sand | D: flood hazard | C: soil & flood hazard | D: flood hazard | C: flood hazard | C: flood hazard | D: flood hazard | D: flood hazard | C: flood water control | D: flood hazard | D: flood hazard & soil water holding capacity of 3-6" | Very Low | Low |
| Pilchuck fine sandy loam<br>Pilchuck sandy loam | D: flood hazard | C: soil & flood hazard | D: flood hazard | C: flood hazard | C: flood hazard | D: flood hazard | D: flood hazard | C: flood water control | D: flood water control | C: flood hazard & soil water holding capacity 5-8" | Very Low | Low |
| Pondilla fine sand 0-3/ | A | B: droughty soil | A | B: droughty soil | A | A | A | D: soil perme-ability, 5.0-10.0 in/hr. | A | C: droughty & low fertility soil | Low | Low |
| Prather silty clay loam | | | | | | | | | | | Very High | High |
| 3-8 | C: soil shrink-swell dangerous | B: soil depth & wetness | D: soil perme-ability, 0.05-0.2 in/hr. | B: seasonal wetness | B: seasonal wetness | C: dense soils & possibly seasonal water table | C: possible seasonal water table | D: slope | B: moisture control | B: soil | | |
| 8-15/ | C: slope & soil | B: soil depth & wetness | | B: seasonal wetness | B: slope wetness | C: as above | D: slope & possible seasonal water table | | C: slope & moisture control | C: slope & soil | | |
| 15-30/ | D: slope & soil | C: slope & soil | | C: slope | D: slope & wetness | D: slope & water table | D: slope & possible seasonal water table | | D: slope & moisture control | D: slope & soil | | |

Table 14. Comparative suitability of soils for suburban uses, Puget Sound Area (con.)

| Soil Series and Type | Suitability of Soils for Uses Cited 1/ | | | | | | | | | | Corrosive Effect of Soil on | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Homesite | | | Community | | | | | Other | | | |
| | Buildings | Land-scaping | Septic Tanks | Parks | Golf Courses | Sanitary Land Fill | Ceme-teries | Sewage Lagoons | Indus-trial | Small Farms and Gardens | Uncoated Steel | Concrete |
| Puget loam<br>Puget silt loam<br>Puget silty clay loam<br>Puget clay loam<br>Puget fine sandy loam<br>Puget very fine sandy loam | D: flood hazard & shrink-swell, moderate to high | B: flood hazard | D: flood hazard & water table | B: flood hazard & wetness | C to D: flood water control | D: flood hazard | D: flood hazard & water table | D: flood hazard | D: flood control, high shrink-swell & very low shearing strength | B: flood hazard | High to Very High | High |
| Puget clay<br>Puget silty clay | D: flood hazard & shrink-swell, moderate to high | B: flood hazard | D: flood hazard | B: flood hazard & wetness | D: flood water control | D: flood hazard | D: flood hazard & water table | D: flood hazard | D: flood control, high shrink-swell & very low shearing strength | C: soil wetness | High to Very High | High |
| Puyallup fine sandy loam<br>Puyallup sandy loam<br>Puyallup very fine sandy loam<br>Puyallup silt loam<br>Puyallup loam | D: flood hazard | B: flood hazard | D: flood hazard | B: flood hazard | B: flood hazard | D: flood hazard | D: flood hazard | D: flood hazard & soil per-meability, 0.8-10.0 in/hr. | C: flood water control and low shearing strength | A | Low<br><br>Low to Moderate | Moderate<br><br>Moderate |
| Puyallup silty clay loam<br>Puyallup loamy sand/Puget | D: flood hazard | B: flood hazard | D: flood hazard & water table | B: flood hazard | B: seasonal wetness | D: flood hazard & water table | D: flood hazard & water table | D: flood hazard & water table | C: flood water con-trol & low shearing strength | B: wetness | Low to Moderate<br>Low | Moderate<br>Low |
| Puyallup fine sandy loam/ Buckley<br>Puyallup sandy loam/Buckley<br>Puyallup loamy fine sand | D: flooding | | D: flood hazard & water table | C: flood hazard & wetness | B: seasonal wetness | D: flood hazard & water table | D: flood hazard & water table | D: flood hazard & water table | C: flood water con-trol & low shearing strength | B: wetness | Low<br><br>Low | Moderate<br><br>Low |

[illegible] of soils for suburban uses, Puget Sound Area (con.)

| [illegible] | Suitability of Soils for Uses Cited 1/ | | | | | | | | | | Corrosive Effect of Soil on | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Homesite | | | Community | | | | | Other | | | |
| | Buildings | Land-scaping | Septic Tanks | Parks | Golf Courses | Sanitary Land Fill | Ceme-teries | Sewage Lagoons | Indus-trial | Small Farms and Gardens | Uncoated Steel | Concrete |
| [illegible] silty clay loam | | | | | | | | | | | High | Moderate |
| 0-15% | B: soil shrink-swell moderate | A | D: bedrock & soil per-meability, 0.05-0.2 in/hr. | A | A | D: bedrock | D: bedrock | D: slope | D: water control | C: soil & slope | | |
| 15-30% | C: slope & soil | B: slope | | B: slope | C: slope | | | | | D: soil & Slope | | |
| over 30% | D: slope | C: slope | | D: slope | D: slope | | | | | | | |
| **Ragnar fine sandy loam** | | | | | | | | | | | Low to Very Low | Moderate |
| 3-8% | A | A | A | A | A | A | A | D: slope | A | B: soil droughty | | |
| 8-15% | B: slope | A | B: slope | A | A | A | B: slope | | B: slope | C: slope | | |
| 15-30% | C: slope | B: slope | D: slope | B: slope | B: slope | D: slope | D: slope | | D: slope | D: slope | | |
| Reed clay Reed silty clay loam | D: flood hazard, dangerous shrink-swell | D: shallow soil & wetness | D: flooding & water table | D: flood hazard & wetness | D: flood hazard & wetness | D: flood hazard & water table | D: flood hazard & water table | D: flooding & water table | D: flood hazard, water control & dangerous shrink-swell | C: wetness & shallow soil | Very High | Moderate |
| Riverwash | D: flood hazard | D: flood hazard | D: flood hazard | D: flood hazard | D: flood hazard | D: flood hazard | D: flood hazard | D: flood hazard | D: flood hazard | D: flood hazard & soil | Low | Moderate |

Table 14. Comparative suitability of soils for suburban uses, Puget Sound Area (con.)

| Soil Series and Type | Suitability of Soils for Uses Cited 1/ | | | | | | | | | | Corrosive Effect of Soil on | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Homesite | | | Community | | | | | Other | | | |
| | Buildings | Land-scaping | Septic Tanks | Parks | Golf Courses | Sanitary Land Fill | Ceme-teries | Sewage Lagoons | Indus-trial | Small Farms and Gardens | Uncoated Steel | Concrete |
| Roche gravelly loam<br>Roche/Rock land complex<br>Roche stony loam<br>Roche/Rock (out-crop complex) | | | | | | | | | | | High | Moderate |
| 0-3% | B: soil & seasonal water table | A | D: soil permeability, less than 0.05 in/hr. | A | A | D: seasonal water table | D: seasonal water table & soil | A | B: water control | A | | |
| 3-8% | B: soil & seasonal water table | A | | A | A | | | D: slope | B | A | | |
| 8-15% | B: slope, soil & water table | A | | A | B: slope | | | | C: slope & water control | C: slope | | |
| 15-30% | C: slope & soil | B | | A | C: slope | | | | D: slope | D: slope | | |
| over 30% | D: slope & soil | C | | D: slope | D: slope | | | | D: slope | D: slope | | |
| Roche stony sandy loam<br>Roche gravelly sandy loam<br>Roche loam | | | | | | | | | | | High | Moderate |
| 0-3% | B: soil & seasonal water table | A | D: soil perme-ability, less than 0.05 in/hr. | A | A | D: seasonal water table | D: seasonal water table | A | B: water control | A | | |
| 3-8% | B: soil & seasonal water table | A | | A | A | | | D: slope | B: water control | A | | |
| 8-15% | C: slope & soil | B: slope | | A | B: slope | | | D: slope | C: slope & water control | C: slope | | |

Table 14. Comparative suitability of soils for suburban uses, Puget Sound Area (con.)

| Soil Series and Type | Suitability of Soils for Uses Cited 1/ | | | | | | | | | | Corrosive Effect of Soil on | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Homesite | | | Community | | | | | Other | | | |
| | Buildings | Land-scaping | Septic Tanks | Parks | Golf Courses | Sanitary Land Fill | Cemeteries | Sewage Lagoons | Industrial | Small Farms and Gardens | Uncoated Steel | Concrete |
| Rock land Rough mountainous land 0-15% | D: soil & slope | D: soil & slope | D: shallow soils & slope | A | D: soil & slope | D: shallow soils & slope | D: shallow soils & slope | D: slope | B: soil | D: soil & slope | Low | Moderate |
| 15-30% | D: soil & slope | D: soil & slope | | A | | | | | C: soil & slope | | | |
| over 30% | D: soil & slope | D: soil & slope | | D: slope | | | | | D: soil & slope | | | |
| Rough broken land Rough stony land | D: steep & variable | D: soil | D: shallow soils & slope | D: soil & slope | D: soil & slope | D: soil & slope | D: shallow soils & slope | D: slope | D: slope & soils | D: soils & slope | Variable | Variable |
| Rough broken land Olympic soil materials | D: steep slopes & variable | C: slope & water table | D: shallow soils 12-48" | D: soil & slope | D: soil & slope | D: shallow soils & bed-rock 12-48" | D: soils 2-4" deep | D: slope | D: soils & slope | D: soils & slope | Moderate | High |
| Salal fine sandy loam Salal silt loam | D: possible flood hazard | B: flood hazard | D: flood hazard | B: flood hazard | B: flood hazard | D: flood hazard | D: flood hazard | D: flood hazard | C: flood water control & soil stability | A | High | Moderate |
| Samish silt loam Samish silty clay loam | D: flood hazard; high shrink-swell | B: flood hazard | D: flood hazard | B: flood hazard | B: flood hazard | D: flood hazard & water table | D: flood hazard & water table | D: flood hazard | C: flood water control & very low shearing strength | B: flood hazard | Moderate | Moderate |
| Sammamish silt loam | D: flood hazard | B: flood hazard | D: flood hazard | B: flood hazard | C: flood water control | D: flood hazard & water table | D: flood hazard & water table | D: flood hazard | D: flood control; high shrink-swell & very low shearing strength | B: flood hazard | High | Moderate |

Table 14. Comparative suitability of soils for suburban uses, Puget Sound Area (con.)

| Soil Series and Type | Suitability of Soils for Uses Cited 1/ | | | | | | | | | | Corrosive Effect of Soil on | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Homesite | | | Community | | | | | Other | | | |
| | Buildings | Land-scaping | Septic Tanks | Parks | Golf Courses | Sanitary Land Fill | Ceme-teries | Sewage Lagoons | Indus-trial | Small Farms and Gardens | Uncoated Steel | Concrete |
| San Juan coarse sandy loam<br>San Juan gravelly sandy loam<br>San Juan stony sandy loam | | | | | | | | | | | Very low | Low |
| 3-8% | B: soil | B: soil droughty | A | B: soil droughty | A | A | A | D: soil per-meability, 5.0-10.0 in/hr. | A | C: soil droughty | | |
| 8-15% | B: soil | B: soil droughty | B: slope | B: soil droughty | B: soil & slope | B: slope | B: slope | | | C: slope & soil | | |
| 15-30% | C: slope & soil | B: soil droughty | D: slope | B: soil droughty | C: slope & soil | D: slope | D: slope | | B: slope | D: slope & soil | | |
| San Juan gravelly sandy loam, mod-erately deep<br>San Juan loam, moderately deep<br>San Juan stony loam, moderately deep | | | | | | | | | | | High | Moderate |
| 3-8% | B: seasonal wetness | A | D: cemented glacial till at 18-24" with perme-ability, 0.05-0.2 in/hr. | A | A | D: cemented glacial till & seasonal water table | D: cemented glacial till at 18-24", & seasonal water table | D: slope | B: soil moisture control | B: soil & seasonal water table | | |
| 8-15% | B: seasonal wetness & slope | A | | A | B: slope | | | | B: soil moisture control & slope | C: slope, soil & seasonal wetness | | |
| 15-30% | C: slope & seasonal wetness | B: slope | | A | C: slope | | | | D: slope | D: slope & soil | | |
| Sauk loam 0-3% | A | A | A | A | A | A | B: slight wetness | B: high piping haz-and & per-meability, 2.5-5.0 in/hr. | A | A | Low | High |
| 3-8% | A | A | A | A | A | A | B: slight wetness | | A | A | | |

Table 14. Comparative suitability of soils for suburban uses, Puget Sound Area (con.)

| Soil Series and Type | Suitability of Soils for Uses Cited 1/ | | | | | | | | | | Corrosive Effect of Soil on | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Homesite | | | Community | | | | | Other | | | |
| | Buildings | Land-scaping | Septic Tanks | Parks | Golf Courses | Sanitary Land Fill | Ceme-teries | Sewage Lagoons | Indus-trial | Small Farms and Gardens | Uncoated Steel | Concrete |
| Saxon silt loam | | | | | | | | | | | Moderate | High |
| 3-8% | B: moderate shrink-swell | A | D: soil perme-ability, 0.05-0.2 in/hr. | A | A | D: cemented glacialtill | D: cemented glacial till at 3-4' | D: slope | B: moisture control | A | | |
| 8-15% | C: slide hazard & shrink-swell | A | | A | B: slope | | | | B: slope & moisture control | B: slope | | |
| 15-30% | D: slope, slide & shrink-swell hazardous | B: slope | | B: slope | D: slope | | | | D: slope | D: slope | | |
| Schnorbush loam Schnorbush loam/ Norma silty clay loam complex (see Norma silty clay loam) | | | | | | | | | | | Moderate | Moderate |
| 8-15% | B: slope | A | C: soil per-meability, 0.2-0.8 in/hr. | A | B: slope | D: bedrock | D: stony & slope | D: slope | B: slope | C: slope | | |
| 15-30% | C: slope | B: slope | D: slope | B: slope | D: slope | | | | | | | |
| Schooley loam | D: very wet unstable soil | D: wetness | D: water table | D: wetness | D: wetness | D: water table | D: water table | D: water table | D: low shearing strength | D: wet soil | Very High | Moderate |
| Semiahmoo | D: low bearing strength, wet | D: wet | D: water table | D: wet | D: wet | D: water table | D: water table | D: water table | C: water control and/or re-move peat. Low bearing strength. | B: wet, water table | Very High | High |
| Sequim clay loam Sequim gravelly loam | B: possible water table | A | D: water table | A | A | D: possible water table | D: possible water table | C: possible water table | B: water control | A | High | Low |

Table 14. Comparative suitability of soils for suburban uses, Puget Sound Area (con.)

| Soil Series and Type | Suitability of Soils for Uses Cited 1/ | | | | | | | | | | Corrosive Effect of Soil on | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Homesite | | | Community | | | | | Other | | | |
| | Buildings | Land-scaping | Septic Tanks | Parks | Golf Courses | Sanitary Land Fill | Cemeteries | Sewage Lagoons | Industrial | Small Farms and Gardens | Uncoated Steel | Concrete |
| Shelton gravelly loam 8-15% | B: slope | A | D: soil permeability, 0.05-0.2 in/hr. | A | B: slope | D: cemented glacial till | D: cemented glacial till | D: slope | B: slope & moisture control | C: slope & soil | Low | Moderate |
| Shelton gravelly sandy loam | | | | | | | | | | | Low | Moderate |
| 3-8% | B: soil | A | D: cemented glacial till | A | A | D: cemented glacial till | D: cemented glacial till at 24-36" | D: slope | B: soil moisture control | B: slope & soil | | |
| 8-15% | B: slope | A | | A | B: slope | | | | B: soil moisture control | B: slope & soil | | |
| 15-30% | C: slope | B: slope | | A | D: slope | | | | D: slope | D: slope | | |
| over 30% | D: slope | D: slope | | C | D: slope | | | | D: slope | D: slope | | |
| Shuwah silty clay loam | D: flood hazard & high shrink-swell | B: flood hazard & wetness | D: flood hazard | B: wetness | B: flood hazard | D: flood hazard | D: flood hazard | D: flood hazard | C: flood water control | A | Moderate | Moderate |
| Sinclair clay loam 3-8% | A | A | D: permeability, 0.05-0.2 in/hr. | A | A | C: cemented glacial till | C: soil, cemented, glacial till | D: slope | B: water control | C: soil | Low to Moderate | Moderate |
| Sinclair shotty loam<br>Sinclair gravelly loam<br>Sinclair gravelly fine sandy loam | | | | | | | | | | | Low to Moderate | Moderate |
| 8-15% | B: soil & slope | A | D: permeability, 0.05-0.2 in/hr. | A | A | C: cemented glacial till | C: slope & soil | D: slope | B: water control | C: slope & soil | | |
| 15-30% | C: slope & soil | B: slope | | B: slope | C: slope | D: slope | D: slope | D: slope | D: slope | D: slope & soil | | |

Table 14. Comparative suitability of soils for suburban uses, Puget Sound Area (con.)

| Soil Series and Type | Suitability of Soils for Uses Cited 1/ | | | | | | | | | | Corrosive Effect of Soil on | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Homesite | | | Community | | | | | Other | | | |
| | Buildings | Land-scaping | Septic Tanks | Parks | Golf Courses | Sanitary Land Fill | Ceme-teries | Sewage Lagoons | Indus-trial | Small Farms and Gardens | Uncoated Steel | Concrete |
| Sinclair gravelly sandy loam | | | | | | | | | | | Low to Moderate | Moderate |
| 3-8% | A | A | D: perme-ability, 0.05-0.2 in/hr. | A | A | C: cemented glacial till | C: slope & soil | D: slope | B: water control | C: slope & soil | | |
| 15-30% | C: slope & soil | B: slope | | B: slope | B: slope | D: slope | D: slope | | slope | D: slope & soil | | |
| over 30% | D: slope | D: slope | | C: slope | D: slope | D: slope | D: slope | | D: slope | D: slope & soil | | |
| Skagit silty clay loam | C: wet, low shearing strength | C: wet, shallow soil | D: soil drainage; perme-ability, less than 0.05 in/hr. | D: very poorly drained wet soil | D: soil drainage | D: water table | D: water table | D: water table | C: very low shear-ing strength. Water control. | D: soil drainage | Very High | Moderate |
| Skiyou gravelly loam | | | | | | | | | | | Moderate | High |
| 3-8% | B: soil; seep areas | A | D: soil perme-ability, 0.05-0.2 in/hr. | A | A | C: cemented glacial till 24-36" | C: cemented glacial till | D: slope | B: moisture control | B: soil | | |
| 8-15% | B: soil | A | | A | A | C: as above | C: slope & cemented glacial till | | B: slope & moisture control | C: slope & soil | | |
| 15-30% | C: slope & soil | A | | A | B: slope | D: slope | D: slope | | D: slope | D: slope & soil | | |
| over 30% | D: slope | D: slope | | D: slope | D: slope | D: slope | D: slope | | D: slope | D: slope | | |
| Skokomish silt loam | D: flood hazard | C: flood hazard | D: water table & flood hazard | D: flood hazard | C: flood water control | D: flood hazard & water table | D: flood hazard & water table | D: flood hazard | D: flood control. Water control & very low shearing strength | C: flood hazard & wetness | High | Moderate |

Table 14. Comparative suitability of soils for suburban uses, Puget Sound Area (con.)

| Soil Series and Type | Suitability of Soils for Uses Cited 1/ | | | | | | | | | | Corrosive Effect of Soil on | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Homesite | | | Community | | | | | Other | | | |
| | Buildings | Land-scaping | Septic Tanks | Parks | Golf Courses | Sanitary Land Fill | Ceme-teries | Sewage Lagoons | Indus-trial | Small Farms and Gardens | Uncoated Steel | Concrete |
| Skykomish cobbly sandy loam<br>Skykomish gravelly sandy loam | | | | | | | | | | | Very Low | Moderate |
| 0-3% | B: soil | C: soil moisture | A | B: soil moisture | A | A | A | D: soil perme-ability, over 10.0 in/hr. | A | C: soil droughty. Water holding capacity, 2.8-3.5" | | |
| 3-8% | B: soil | C: soil moisture | | | | | | | | | | |
| 8-15% | B: soil | C: soil moisture | | | | | | | | | | |
| 15-30% | C: slope & soil | C: soil moisture | | | B: slope & soil | | | | B: slope | | | |
| Skykomish gravelly loam<br>Skykomish stony loam 3-8% | B: soil | B: soil moisture | A | A | A | A | A | D: soil perme-ability, over 10.0 in/hr. | A | C: soil droughty. Water holding capacity, 2.8-3.5" | Very Low | Moderate |
| Skykomish stony sand<br>Skykomish gravelly sand 3-8% | C: soil texture | C: soil moisture | A | C: soil moisture | B: soil texture & moisture | A | B: soil | D: soil perme-ability, over 10.0 in/hr. | A | D: soil texture & low moisture holding | Very Low | Moderate |
| Smith Creek grav-elly loam - 3-8% | A | B: soil moisture | A | A | A | A | A | D: soil perme-ability, 5.0-10.0 in/hr. | A | C: soil droughty; 4.5-6.0" water-holding capacity | Very Low | Moderate |
| 15-30% | B: slope | B: soil moisture | D: slope | A | C: slope | D: slope | D: slope | | D: slope | D: slope | | |

Table 14. Comparative suitability of soils for suburban uses, Puget Sound Area (con.)

| Soil Series and Type | Suitability of Soils for Uses Cited 1/ | | | | | | | | | | Corrosive Effect of Soil on | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Homesite | | | Community | | | | | Other | | | |
| | Buildings | Land-scaping | Septic Tanks | Parks | Golf Courses | Sanitary Land Fill | Ceme-teries | Sewage Lagoons | Indus-trial | Small Farms and Gardens | Uncoated Steel | Concrete |
| Snakelum coarse sandy loam 8-15% | C: soil & slope | B: soil moisture 5-6" | B: slope | A | B: slope | B: slope | B: slope | D: soil perme-ability, 5-10.0 in/hr. | B: slope | C: slope & soil; moisture-holding capacity 5-6" | Very Low | Moderate |
| Snohomish fine sandy loam<br>Snohomish loamy fine sand<br>Snohomish loam<br>Snohomish silt loam<br>Snohomish silty clay<br>Snohomish silty clay loam | D: flood hazard & low bearing capacity | C: wetness & flooding | D: water table & flooding | D: flood hazard & wetness | B: flood hazard | D: water table & flood hazard | D: water table & flood hazard | D: water table & flood hazard | C: water control & low bearing strength | B: wetness | Very High | High |
| Snoqualmie gravelly loam 3-8% | A | B: droughty soil | A | A | A | A | A | D: perme-ability, 5.0-10.0 in/hr. | A | B: moisture holding capacity, 4-5" | Very Low | Moderate |
| Snoqualmie grav-elly sandy loam<br>Snoqualmie grav-elly loamy sand 3-8% | A | B: droughty soil | A | A | A | A | A | D: perme-ability, 5.0-10.0 in/hr. | A | C: droughty soil | Very Low | Moderate |
| Sol Duc Gravelly loam<br>Sol Duc gravelly sandy loam 0-3% | A | B: soil moisture 4" | A | A | A | A | A | D: perme-ability, 5.0-10.0 in/hr. | A | C: soil moisture 4" | Very Low | High |

Table 14. Comparative suitability of soils for suburban uses, Puget Sound Area (con.)

| Soil Series and Type | Suitability of Soils for Uses Cited 1/ | | | | | | | | | | Corrosive Effect of Soil on | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Homesite | | | Community | | | | | Other | | | |
| | Buildings | Land-scaping | Septic Tanks | Parks | Golf Courses | Sanitary Land Fill | Ceme-teries | Sewage Lagoons | Indus-trial | Small Farms and Gardens | Uncoated Steel | Concrete |
| Sol Duc gravelly loam 8-15% | B: slope & soil | B: soil moisture 4" | B: slope | A | B: slope | A | B: slope | D: perme-ability, 5.0-10.0 in/hr. | A | C: slope & soil | Very Low | High |
| Spalding peat<br>Spalding peat, burned | D: low bearing capacity; wet | D: wet | D: water table | D: wet un-stable soil | D: wet | D: water table | D: water table | D: water table | D: unstable & low bearing capacity | D: low fertility & very wet | Very High | High |
| Spanaway gravelly sandy loam<br>Spanaway stony sandy loam<br>Spanaway stony loam | | | | | | | | | | | Very Low | Low |
| 0-3% | A | B: soil droughty; moisture 5-6" | A | A | A | A | A | D: soil perme-ability, 5.0-10.0 in/hr. | A | B: soil droughty; moisture 5-6" | | |
| 3-8% | A | B: soil droughty; moisture 5-6" | A | A | A | A | A | | A | B: slope & soil | | |
| 8-15% | B: slope | B: soil droughty; moisture 5-6" | B: slope | A | B: slope | B: slope | A | | A | C: slope & soil | | |
| 15-30% | C: slope | B: soil droughty; moisture 5-6" | C: slope | A | C: slope | D: slope | D: slope | | D: slope | | | |
| Squalicum silt loam 8-15% | C: slope & dangerous shrink-swell | B: soil depth 20-30" | D: perme-ability, less than 0.05 in/hr. | A | B: slope | D: slope & unstable soil | D: cemented glacial till at 20-30"; possible water table | D: slope | C: soil moisture control; very low shearing strength | C: slope & unstable soil | High | High |

Table 14. Comparative suitability of soils for suburban uses, Puget Sound Area (con.)

| Soil Series and Type | Suitability of Soils for Uses Cited 1/ | | | | | | | | | | Corrosive Effect of Soil on | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Homesite | | | Community | | | | | Other | | | |
| | Buildings | Land-scaping | Septic Tanks | Parks | Golf Courses | Sanitary Land Fill | Ceme-teries | Sewage Lagoons | Indus-trial | Small Farms and Gardens | Uncoated Steel | Concrete |
| Squalicum silt loam 15-30% | D: slope & dangerous shrink-swell | C: slope & soil depth | | A | C: slope | D: slope & unstable soil | | | D: slope & soil | D: slope & unstable soil | High | High |
| Squalicum/Alderwood silt loams<br>Squalicum gravelly silt loam<br>Squalicum stony silt loam<br>Squalicum/Alderwood stony silt loam | | | | | | | | | | | High | High |
| 0-3% | C: dangerous shrink-swell | B: soil depth 20-30" | D: perme-ability, less than 0.05 in/hr. | A | A | D: cemented glacial till | D: cemented glacial till at 20-30"; possible water table | C: soil stability | C: soil moisture control | B: shallow soil | | |
| 3-8% | C: dangerous shrink-swell | B: soil depth 20-30" | | A | A | D: cemented glacial till | | D: slope | C: very low shearing strength | B: shallow soil | | |
| 8-15% | C: slope & soil | B: soil depth 20-30" | | A | B: slope | D: slope & soil | | D: slope | C | C: slope & shallow soil | | |
| 15-30% | D: slope & soil | C: slope & soil | | A | C: slope | D: slope & soil | | | D: slope & soil | D: slope & unstable soil | | |
| over 30% | D: slope & soil | D: slope & soil | | D: soil stability | D: slope | D: slope & soil | | D: slope | D: slope & soil | D: slope & unstable soil | | |
| Steep broken land (see adjacent Alderwood, Everett, Kitsap, or Indianola soils) | Variable | . . . . . . | | See individual soil types and phases | | | | D: slope | | | Variable | Variable |

Table 14. Comparative suitability of soils for suburban uses, Puget Sound Area (con.)

| Soil Series and Type | Suitability of Soils for Uses Cited 1/ | | | | | | | | | | Corrosive Effect of Soil on | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Homesite | | | Community | | | | | Other | | | |
| | Buildings | Land-scaping | Septic Tanks | Parks | Golf Courses | Sanitary Land Fill | Ceme-teries | Sewage Lagoons | Indus-trial | Small Farms and Gardens | Uncoated Steel | Concrete |
| Stossel clay loam<br>Stossel stony loam | | | | | | | | | | | Very High | Low |
| 8-15% | C: dangerous shrink-swell & slope | C: rooting soil depth 12-24" | D: perme-ability, less than 0.05 in/hr. | C: slope & unstable soil | B: slope | D: depth over shale 3-6' | D: seep areas & depth of soil 3-6' | D: slope | C: slope, soil moisture & unstable soil | D: slope & soil | | |
| 15-30% | D: slope, shrink-swell & very low shearing strength | D: slope & soil | | D: slope & unstable soil | D: slope | | | | D: slope | | | |
| Sultan silt loam<br>Sultan loam<br>Sultan clay loam<br>Sultan fine sandy loam<br>Sultan loamy sand | D: flood hazard | B: flood hazard | D: flood hazard & water table | B: flood hazard | B: flood hazard | D: flood hazard & water table | D: flood hazard & wetness | D: flood hazard | C: water control, flood & soil moisture. Very low shearing strength. | B: flood hazard | Moderate<br>Moderate to High<br>Moderate | Slight<br>Slight<br>Slight |
| Sultan silt loam, shallow/Buckley<br>Sultan silt loam, moderately deep/Buckley | D: flood hazard | B: flood hazard | D: flood hazard & water table | B: flood hazard | B: flood hazard | D: flood hazard & water table | D: flood hazard & water table | D: flood hazard | C: flood & water con-trol; soil moisture; very low shearing strength | B: flood hazard | Moderate | Slight |
| Sumas silt loam<br>Sumas fine sandy loam<br>Sumas silty clay loam | D: flood hazard & water table | B: flood hazard | D: flood hazard & water table | B: flood hazard | B: flood hazard | D: flood hazard & water table | D: flood hazard & water table | D: flood hazard | C: flood & water control; moderate shrink-swell & very low shearing strength | B: flood hazard & wetness | High | Moderate |

Table 14. Comparative suitability of soils for suburban uses, Puget Sound Area (con.)

| Soil Series and Type | Suitability of Soils for Uses Cited 1/ | | | | | | | | | | Corrosive Effect of Soil on | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Homesite | | | Community | | | | | Other | | | |
| | Buildings | Land-scaping | Septic Tanks | Parks | Golf Courses | Sanitary Land Fill | Ceme-teries | Sewage Lagoons | Indus-trial | Small Farms and Gardens | Uncoated Steel | Concrete |
| Swantown gravelly loam 3-8 | B: soil | soil depth 14-20" | D: soil perme-ability, less than 0.05 in/hr. | A | A | D: very dense glacial till | D: very dense glacial till | D: slope | B: moisture control. Low shearing strength. | C: shallow soils 14-20" | Moderate | Moderate |
| Swantown loam 0-3% | B: soil | C: soil depth 14-20" | D: perme-ability, less than 0.05 in/hr. | A | A | | | B: soil | B: moisture control; low shearing strength | C: shallow soil | Moderate | Moderate |
| 8-15% | B: soil | C: soil depth 14-20" | | A | B: slope | D: very dense gla-cial till | D: very dense gla-cial till | D: slope | | C: slope & soil | | |
| Swantown gravelly sandy loam 0-3% | B: soil | C: soil depth 14-20" | D: soil perme-ability, less than 0.05 in/hr. | A | A | D: very dense gla-cial till | D: very dense gla-cial till | B: soil | B: moisture control; low bearing strength | C: shallow soils 14-20" | Moderate | Moderate |
| 3-8% | B: soil | C | | A | A | | | D: slope | | C: shallow soils 14-20" | | |
| 8-15% | B: soil | C | | A | B: slope | | | D: slope | | C: slope & soil | | |
| Tacoma muck Tacoma peat | D: very wet; low bearing strength | D: wet | D: flooding & water table | D: very wet | D: very wet | D: water table | D: water table | D: flooding & water table | C: water control & very unsta-ble soils | C: very wet soils | Very High | High |
| Tanwax peat Tanwax peat, shallow/Mukilteo peat | D: very wet; low bearing strength | D: wet | D: flooding & water table | D: very wet | D: very wet | D: water table | D: water table | D: flooding & water table | C: water control & very unstable soils | C: very wet soils | Very High | High |

Table 14. Comparative suitability of soils for suburban uses, Puget Sound Area (con.)

| Soil Series and Type | Suitability of Soils for Uses Cited 1/ | | | | | | | | | | Corrosive Effect of Soil on | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Homesite | | | Community | | | | | Other | | | |
| | Buildings | Land-scaping | Septic Tanks | Parks | Golf Courses | Sanitary Land Fill | Ceme-teries | Sewage Lagoons | Indus-trial | Small Farms and Gardens | Uncoated Steel | Concrete |
| Tebo gravelly loam | | | | | | | | | | | Moderate | Moderate |
| 8-15% | B: shrink-swell & very low shearing strength | A | C: soil perme-ability, & soil depth | A | C: slope | D: bedrock 36-60" | D: bedrock 36-60" | D: slope | C: moisture control & slope | C: slope | | |
| 15-30% | C: slope, & as above | B: slope | | B: slope | D: slope | | | | D: slope | D: slope | | |
| over 30% | D: slope, & as above | C: slope | D: slope | C: slope | D: slope | | | | D: slope | D: slope | | |
| Tebo loam | | | | | | | | | | | Moderate | Moderate |
| 8-15% | B: slope & very low shearing strength | A | C: soil perme-ability, & soil depth | A | C: slope | | | D: slope | C: moisture control & slope | C: slope | | |
| 15-30% | B: slope & very low shearing strength | C: slope | D: slope | B: slope | D: slope | | | | D: slope | D: slope | | |
| Tenino gravelly sandy loam | | | | | | | | | | | Moderate | Moderate |
| 8-15% | B: slope | A | C: soil perme-ability, 0.2-0.8 in/hr. | A | B: slope | B: moder-ately ce-mented gla-cial till & slope | B: moder-ately ce-mented gla-cial till | D: slope | B: moisture control | C: slope | | |
| 15-30% | C: slope | A | D: slope | A | C: slope | D: slope & soil | D: slope & soil | | | D: slope | | |
| Thornton clay Thornton silty clay loam | | | | | | | | | | | Very High | Low |
| 0-3% | D: danger-ous shrink-swell; very poorly drained | C: very wet, shallow soil | D: water table | D: wetness | D: wetness | D: water table | D: water table | D: water table & unstable soils | C: moisture control; unstable micaceous soil | C: very poorly drained | | |

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Table 14. Comparative suitability of soils for suburban uses, Puget Sound Area (con.)

| Soil Series and Type | Suitability of Soils for Uses Cited 1/ | | | | | | | | | | Corrosive Effect of Soil on | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Homesite | | | Community | | | | | Other | | | |
| | Buildings | Land-scaping | Septic Tanks | Parks | Golf Courses | Sanitary Land Fill | Ceme-teries | Sewage Lagoons | Indus-trial | Small Farms and Gardens | Uncoated Steel | Concrete |
| Thornwood gravelly loam<br>Thornwood gravelly sandy loam | | | | | | | | | | | Low | Moderate |
| 0-3% | A | A | A | A | A | A | A | D: perme-ability, 5.0-10.0 in/hr. | A | C: soil moisture 5-6" | | |
| 3-8% | A | A | A | A | A | A | A | | A | C: soil moisture 5-6" | | |
| 8-15% | B: slope | A | B: slope | B: slope | B: slope | C: slope | C: slope | | B: slope | C: slope & soil | | |
| 15-30% | C: slope | B: slope | C: slope | C: slope | C: slope | D: slope | D: slope | | C: slope | D: slope | | |
| over 30% | D: slope | C: slope | D: slope | D: slope | D: slope | D: slope | D: slope | | D: slope | D: slope | | |
| Tidal marsh | D: very wet, & low bearing strength | D: very wet | D: water table & flooding | D: very wet | D: very wet | D: water table | D: water table | D: water table | D: very low bearing strength & very wet | D: very wet, & flooding | Very High | Low |
| Tisch silt loam<br>Tisch silty clay loam | D: very poorly drained; very low shearing strength | D: very wet | D: water table | C: water control; very wet | C: very wet; drainage | D: water table | D: water table | D: water table | C: water control; very low shearing strength | C: wetness | Very High | Very High |
| Tokul gravelly sandy loam | | | | | | | | | | | Low | Moderate |
| 8-15% | B: slope | A | D: perme-ability, 0.05-0.2 in/hr. | A | A | A | C: cemented glacial till | D: slope | B: moisture control | C: slope | | |
| Townsend gravelly loam 0-3% | A | A | D: perme-ability, 0.05-0.2 in/hr. | A | A | D: cemented glacial till | C: cemented glacial till at 20-30" | B: piping hazard through berm | A | C: soil depth & fertility | Low | Moderate |

Table 14. Comparative suitability of soils for suburban uses, Puget Sound Area (con.)

| Soil Series and Type | Suitability of Soils for Uses Cited 1/ | | | | | | | | | | Corrosive Effect of Soil on | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Homesite | | | Community | | | | | Other | | | |
| | Buildings | Land-scaping | Septic Tanks | Parks | Golf Courses | Sanitary Land Fill | Ceme-teries | Sewage Lagoons | Indus-trial | Small Farms and Gardens | Uncoated Steel | Concrete |
| Townsend fine sandy loam | | | | | | | | | | | Low | Moderate |
| 0-3% | A | A | | A | A | | C | D: slope | A | C: soil depth & fertility | | |
| 8-15% | B: slope | A | | B: slope | B: slope | | C | D: slope | B: slope | C: soil depth & fertility | | |
| Triton very gravelly loam | | | | | | | | | | | Low | Moderate |
| 15-30% | C: slope & soil depth | C: shallow soil 12-20" | D: perme-ability, less than 0.05 in/hr. | C: soil | D: slope & soil | D: cemented glacial till | D: soil depth 12-20" over cemented glacial till | D: slope | D: slope | D: slope & soil | | |
| over 30% | D: slope | D: slope | | D: soil & slope | D: soil & slope | | | | | | | |
| Tromp silt loam<br>Tromp silty clay loam<br>Tromp-Edmonds silt loams (see Edmonds silt loam)<br>Tromp-Custer silt loams (see Custer silt loams)<br>Tromp-Woodlyn silt loams (see Woodlyn silt loam)<br>Tromp-Tisch silt loams, complex (see Tisch silt loam) | C: drainage required; possible settling when drained | B: possible wetness | D: water table | C: wetness | B: when drained | D: possible water table | D: water table | D: water table | C: water control | B: wetness | High | Low |

Table 14. Comparative suitability of soils for suburban uses, Puget Sound Area (con.)

| Soil Series and Type | Suitability of Soils for Uses Cited 1/ | | | | | | | | | | Corrosive Effect of Soil on | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Homesite | | | Community | | | | | Other | | | |
| | Buildings | Land-scaping | Septic Tanks | Parks | Golf Courses | Sanitary Land Fill | Ceme-teries | Sewage Lagoons | Indus-trial | Small Farms and Gardens | Uncoated Steel | Concrete |
| Tumwater loamy fine sand | | | | | | | | | | | Low | Low |
| 0-3% | B: soil | B: soil moisture 5.6-6.0" | A | A | A | A | A | D: perme-ability, 5.0-10.0 in/hr. | A | C: soil moisture 5.6-6.0" | | |
| 8-15% | B: soil | B: soil moisture 5.6-6.0" | B: slope | B: slope & soil | B: slope | B: slope | C: slope | | B: slope | C: slope & soil | | |
| 15-30% | C: slope & soil | C: slope | D: slope | C: slope & soil | D: slope | D: slope | D: slope | | D: slope | D: slope | | |
| Tumwater fine sandy loam | | | | | | | | | | | Low | Low |
| 0-3% | B: soil | B: soil | A | A | A | A | A | | A | C: soil moisture | | |
| Waddell loam | | | | | | | | | | | Moderate | Moderate |
| 3-8% | C: moisture control expansion dangerous | A | B: soil per-meability, 0.2-0.8 in/hr. | A | A | B: soil | A | D: slope | B: soil moisture control | B: soil | | |
| Waddell gravelly loam 3-8% & 8-15% | C: slope & moisture control | A | B: soil per-meability, 0.2-0.8 in/hr. | A | B: slope | B: soil | A | | | C: slope | Moderate | Moderate |
| Waddell silty clay loam | | | | | | | | | | | Moderate | Moderate |
| 0-3% | C: moisture control; expansion dangerous | A | B: soil per-meability, 0.2-0.8 in/hr. | A | A | B: soil | B: soil drainage | | | B: soil | | |

Table 14. Comparative suitability of soils for suburban uses, Puget Sound Area (con.)

| Soil Series and Type | Suitability of Soils for Uses Cited 1/ | | | | | | | | | | Corrosive Effect of Soil on | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Homesite | | | Community | | | | | Other | | | |
| | Buildings | Land-scaping | Septic Tanks | Parks | Golf Courses | Sanitary Land Fill | Ceme-teries | Sewage Lagoons | Indus-trial | Small Farms and Gardens | Uncoated Steel | Concrete |
| Wapato silty clay loam<br>Wapato clay loam<br>Wapato silty clay loam-Galvin silty clay loam complex<br>Wapato silt loam | D: flood hazard; shrink-swell dangerous | C: wetness | D: water table | D: flood hazard & wetness | D: flood hazard & wetness | D: flood hazard & water table | D: flood hazard & water table | D: flood hazard & water table | C: flood & moisture control | B: flood hazard | Very High | Moderate |
| Whatcom silt loam<br>Whatcom silt loam-McKenna silty clay loam complex (see McKenna silty clay loam) | | | | | | | | | | | High | Moderate |
| 3-8% | C: expansion may be dangerous | B: soil depth | D: perme-ability, less than 0.05 in/hr. | A | A | D: dense substratum & possible water table | D: dense substratum & possible water table | D: slope | B: soil moisture control | B: soil & slope | | |
| 8-15% | C: slope & soil expansion | B: soil depth | | B: slope | B: slope | | | | C: slope & soil | C: slope | | |
| 15-30% | C: slope, soil expan-sion & stability | C: slope & soil | | C: slope | C: slope | | | | D: slope & soil | D: slope | | |
| over 30% | D: slope | D: slope | | D: slope | D: slope | | | | D: slope | D: slope | | |
| Whidbey gravelly sandy loam<br>0-3% | B: soil 2-3' deep over cemented till | B: soil depth 2-3' | D: perme-ability, 0.05-0.2 in/hr. | A | A | D: strongly cemented glacial till | D: strongly cemented glacial till at 2-3' | C: soil | A | C: soil depth 2-3' & moisture-holding capacity 2.8-3.5" | Moderate | Moderate |
| 3-8% | B: as above | B: soil depth 2-3' | | A | A | | | D: slope | A | | | |
| 8-15% | B: slope & soil | B: soil depth 2-3' | | A | B: slope | | | D: slope | B: slope | | | |
| 15-30% | C: slope & soil | C: slope & soil | | B: soil | C: slope | | | D: slope | D: slope | | | |

Table 14. Comparative suitability of soils for suburban uses, Puget Sound Area (con.)

| Soil Series and Type | Suitability of Soils for Uses Cited 1/ | | | | | | | | | | Corrosive Effect of Soil on | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Homesite | | | Community | | | | | Other | | | |
| | Buildings | Land-scaping | Septic Tanks | Parks | Golf Courses | Sanitary Land Fill | Ceme-teries | Sewage Lagoons | Indus-trial | Small Farms and Gardens | Uncoated Steel | Concrete |
| Wickersham shaly loam Wickersham shaly silt loam | | | | | | | | | | | Low | Low |
| 0-3% | B: schist soils; unstable | A | A | A | A | A | A | D: soils unstable | A | A | | |
| 3-8% | B: schist soils; unstable | A | A | A | A | A | A | | A | A | | |
| Wilkeson loam Wilkeson silt loam | | | | | | | | | | | High | Moderate |
| 8-15% | B: slope | A | D: perme-ability, less than 0.05 in/hr. | B: slope | B: slope | D: dense clay at 30-36" | D: dense clay at 30-36"; water table | D: slope | C: slope & moisture control | C: slope | | |
| 15-30% | C: slope | B: slope | | C: slope | C: slope | | | | D: slope | D: slope | | |
| Winston gravelly sandy loam | A | B: soil moisture | A | A | A | A | A | D: soil perme-ability, 5.0-10.0 in/hr. | A | C: soil moisture | Low | Moderate |
| Woodinville silt loam | C: flood hazard & low bearing strength | C: wetness | D: water table | C: wetness & drainage | C: wetness & drainage | D: water table | D: water table | D: periodic overflow | C: flood water & moisture control | C: wetness & drainage | High | High |
| Woodlyn silt loam | C: soil drainage | A | D: water table | B: wetness | B: wetness | D: water table | D: water table | C: possible water table | C: water & moisture control | B: wetness & drainage | Very High | High |

# ENGINEERING INTERPRETATIONS OF SOILS

Soil properties affect construction and maintenance of roads, airports, pipelines, foundations, erosion control structures, drainage, sewage disposal, and water storage facilities. The properties most important to the engineer are permeability to water, soil texture, shearing strength, plasticity, and reaction (pH). Depths to water table, bedrock, and unconsolidated materials, as well as topography, are important.

Tables 15 and 16 contain information that can be used by engineers to:

1. Make soil and land use studies that will aid in the selection and development of industrial, business, residential, and recreational sites.

2. Assist in designing drainage and irrigation systems, farm ponds, diversion terraces, and other structures for soil and water conservation.

3. Make estimates of runoff and sediment characteristics for use in planning dams, channels, and other structures.

4. Make preliminary evaluations of soil and ground conditions that will aid in selecting highway and airport locations, and in planning of detailed soils investigations for design purposes.

5. Locate possible sources of sand, gravel, and other construction materials.

6. Determine the suitability of soil units for cross-country movement of vehicles and construction and logging equipment.

7. Supplement information obtained from other published maps, reports, and aerial photographs for the purpose of making maps and reports that can be used readily by engineers.

It is not intended that this report will eliminate the need for sampling and testing of soils for specific engineering work. The soils maps and this report are generalized and should be used only in planning more detailed investigations of specific sites.

The use of data presented in engineering soil interpretations tables in this report will provide a preliminary evaluation of engineering properties of soils at any specific location.

## ENGINEERING SOIL CLASSIFICATION SYSTEMS

Most highway engineers classify soil materials according to the system approved by the American Association of State Highway officials. In this system, soil materials are classified in seven principal groups. The groups range from A-1, which consists of *gravelly soils of high bearing* capacity, to A-7, which consists of clay soils having low strength when wet.

*Some engineers prefer to use the unified soil classification system.* In this system, soil materials are identified as coarse grained, eight classes; fine grained, six classes; and highly organic soils. An approximate classification of soils by this system can be made in the field. Soils classified according to both systems are included in Tables 15 and 16 of this report.

Table 15. Soil features affecting engineering practices on highways, Puget Sound Area

| Soil Series and Type | Engineering Classification | | Suitability as Source of | | | | Highway Location and Trafficability |
|---|---|---|---|---|---|---|---|
| | Unified | AASHO | Topsoil | Sand | Gravel | Roadfill | |
| Active dune land | SP 1/<br>SP 2/ | A-3, A-3 | Very poor | Excellent | Very poor | Good | Susceptibility to frost action: none. Shearing strength: high. Load carrying capacity: high. Shrink-swell potential: low. Permeability: subsoil, 5.0-10.0; substratum, 5.0-10.0 3/ |
| Agnew-Elwha complex | CL-GM | A-6, A-1 | Fair to not suitable | Not suitable | Not suitable | Subsoil: not suitable, Substratum: good | Susceptibility to frost action: moderate to high. Shearing strength moderate to very low. Load carrying capacity: high to moderate. Shrink-swell potential: moderate to low. Permeability: subsoil, 0.05-0.2; substratum, 0.05-0.2 |
| Agnew silty clay loam | CL-GM | A-6, A-1 | Fair to not suitable | Not suitable | Not suitable | Subsoil: not suitable, Substratum: good | Susceptibility to frost action: moderate to high. Shearing strength: high to moderate. Load carrying capacity: high to moderate. Shrink-swell potential: moderate to low. Permeability: subsoil, 0.05-0.2; substratum, 0.05-0.2 |
| Agnew silt loam<br>Agnew loam<br>Agnew fine sandy loam<br>Agnew sandy loam | CL | A-6 | Fair to good | Not suitable | Not suitable | Good to poor | Susceptibility to frost action: moderate to very high. Shearing strength: moderate to low. Load carrying capacity: low to moderate. Shrink-swell potential: moderate to low. Permeability: 0.05-0.2 |
| Alderwood gravelly loam | SM-GM<br>SM | A-1, A-2<br>A-1, A-2 | Fair | Good to poor | Very poor to not suitable | Good | Susceptibility to frost action: slight to high. Shearing strength: high. Load carrying capacity: high. Shrink-swell potential: low Permeability: subsoil, 0.8-2.5; substrata, 0.05-0.2 |
| Alderwood grav. sandy loam<br>Alderwood fine sandy loam<br>Alderwood loamy sand<br>Alderwood stony loam | SM-GM<br>SM-GM | A-1, A-2<br>A-1 | Fair | Good to poor | Very poor to not suitable | Good | Substrata at 2.5-4.0 feet consists of cemented sandy glacial till. May be subject to seasonal water table and seep areas. |
| Alderwood silt loam<br>Alderwood loam | SM<br>SM-GM | A-2 | Good | Poor | Very poor to not suitable | Fair to good | |
| Alluvial soils undifferentiated | OL-ML<br><br>ML-MH | A-5, A-7<br>A-6<br>A-4, A-7 | Good | Not suitable | Not suitable | Very poor to fair | Susceptibility to frost action: high to very high. Shear.strength moderate tovery low. Load carrying capacity: low. May be subject to periodic overflow & high water table. May become "quick" if wet. Permeability: Variable 0.05-10.0 |
| Ahl very gravelly silt loam | GM<br>GM | A-1<br>A-1 | Not suitable | Not suitable | Poor | Good | Susceptibility to frost action: slight. Sheating strength: high to moderate. Load carrying capacity: high. Shrink-swell potential: low. Basalt bedrock at 3 to 4 feet. Permeability: subsoil, 0.8-2.5; substratum, less than 0.05 |
| Astoria silt loam | CL-CH | A-7-6<br>A-7-6 | Fair to poor | Not suitable | Not suitable | Not suitable | Susceptibility to frost action: moderate to high. Shearing strength: mod. to very low. Load carrying capacity: high, except when wet. Shrink-swell potential: high. May be subj. to seep areas. Permeability: 0.05-0.2 |

1/ subsoil 2/ substratum 3/ Permeability shown in inches per hour

Table 15. Soil features affecting engineering practices on highways, Puget Sound Area (con.)

| Soil Series and Type | Engineering Classification | | Suitability as Source of | | | | Highway Location and Trafficability |
|---|---|---|---|---|---|---|---|
| | Unified | AASHO | Topsoil | Sand | Gravel | Roadfill | |
| Barneston grav. fine sandy loam<br>Barneston grav. loamy sand | GM<br>GW | A-2<br>A-1 | Not suitable | Very poor | Excellent | Good | Susceptibility to frost action: slight. Shearing strength: very high. Load carrying capacity: high. Shrink-swell potential: low. Permeability: subsoil, 2.5-5.0; substrata, 5.0-10.0 |
| Barneston silt loam<br>Barneston-Wilkeson complex | SM<br>SM | A-2<br>A-2 | Fair | Poor | Poor | Good | Susceptibility to frost action: slight. Shearing strength: moderate. Load carrying capacity: high. Shrink-swell potential: low Permeability: subsoil, 2.5-5.0; substrata, 5.0-10.0 |
| Barneston stony silt loam | GM<br>GM | A-1<br>A-1 | Not suitable | Poor | Good | Good | Susceptibility to frost action: slight. Shearing strength: high to mod. Load carrying capacity: high. Shrink-swell potential: low. Permeability: subsoil, 2.5-5.0; substratum, 5.0-10.0 |
| Barnhardt gravelly sandy loam | SM<br>SM | A-4<br>A-2 | Fair | Poor | Very poor | Good | Susceptibility to frost action: slight. Shearing strength: high to mod. Load carrying capacity: high. Shrink-swell potential: low. Permeability: subsoil, 2.5-5.0; substratum, 5.0-10.0 |
| Barnhardt gravelly silt loam | ML<br>CL-SM | A-4<br>A-2 | Fair to good | Not suitable | Not suitable | Fair to very poor | Susceptibility to frost action: moderate to high. Shearing strength: mod. to low. Load carrying capacity: low to mod. Low shrink-swell Permeability: subsoil, 2.5-5.0; substratum, 5.0-10.0 |
| Belfast silt loam<br>Belfast silty clay loam | MH<br>MH | A-7<br>A-7 | Good | Not suitable | Not suitable | Very poor | Susceptibility to frost action: very high. Shearing strength: very low. Load carrying capacity: low. Shrink-swell potential: high Permeability: 0.2-0.8 May be subject to periodic overflow. |
| Belfast fine sandy loam<br>Belfast sandy loam | SM-ML<br>SM-SC | A-4<br>A-2, A-4 | Good | Poor | Not suitable | Fair to good | Susceptibility to frost action: slight to high. Shearing strength: high to mod. Load carrying capac. high, except when wet. Shrink-swell potential: low. May be subj. to periodic overflow. Permeability: subsoil, 0.2-0.8; substrata, 0.2-0.8 |
| Bellingham clay<br>Bellingham silty clay | ML-CL<br>CL | A-4, A-6<br>A-7 | Fair to good | Not suitable | Not suitable | Very suitable | Susceptibility to frost action: high. Shearing strength: moderate. Load carrying capacity: moderate to low. Shrink-swell potential: high. May have high water table. May become "quick" when wet. Permeability: 0.05-0.2 |
| Bellingham clay loam<br>Bellingham silty clay loam | ML<br>CL-OL | A-4<br>A-6, A-7 | Fair | Not suitable | Not suitable | Not suitable | Susceptibility to frost action: high. Shearing strength: mod. to very low. Load carrying capacity: low, except when dry. May have high water table and become "quick" when wet. High shrink-swell. Permeability: subsoil, 0.05-0.2; substrata, less than 0.05 |
| Bellingham silt loam<br>Bellingham loam | OL-CH<br>CL | A-7<br>A-7 | Good | Not suitable | Not suitable | Very poor | Susceptibility to frost action: moderate to high. Shearing strength: very low. Load carrying capacity: low. Shrink-swell potential: moderate to high. May have high water table. May become "quick" when wet. Permeability: 0.05-0.2. Slow to very slow |

Table 15. Soil features affecting engineering practices on highways, Puget Sound Area (con.)

| Soil Series and Type | Engineering Classification | | Suitability as Source of | | | | Highway Location and Trafficability |
|---|---|---|---|---|---|---|---|
| | Unified | AASHO | Topsoil | Sand | Gravel | Roadfill | |
| Bow silt loam<br>Bow silt loam, shallow<br>Bow silty clay loam<br>Bow-Bellingham silty clay loams | CL<br>CL | A-6, A-7<br>A-7 | Fair | Not suitable | Not suitable | Very poor | Susceptibility to frost action: high. Shearing strength: moderate to low. Load carrying capacity: moderate. May have seasonal water table and seep areas. Shrink-swell potential: high.<br>Permeability: subsoil, 0.05-0.2; substrata, Less than 0.05 |
| Bow stony silt loam<br>Bow gravelly loam<br>Bow gravelly silt loam | ML-CL<br>CL-CH | A-7, A-6<br>A-6, A-7 | Good | Not suitable | Not suitable | Fair to poor | Susceptibility to frost action: moderate to high. Shearing strength: moderate to very low. Load carrying capacity: high when dry; low when wet. Seasonal water table. Shrink-swell potential: high.<br>Permeability: subsoil, 0.05-0.2; substrata, less than 0.05 |
| Bow clay loam | CL<br>CL-CH | A-6, A-7<br>A-6, A-7 | Fair | Not suitable | Not suitable | Poor to very poor | Susceptibility to frost action: moderate to high. Shearing strength: moderate to very low. Load carrying capacity: high when dry; low when wet. Seasonal water table. Shrink-swell potential: high.<br>Permeability: subsoil, 0.05-0.2; substrata, less than 0.05 |
| Bozarth fine sandy loam | SM<br>SM | A-2<br>A-1, A-2 | Fair | Good to poor | Not suitable | Good | Susceptibility to frost action: slight. Shearing strength: high to mod. Load carrying capacity: high: Shrink-swell potential: low<br>Permeability: subsoil, 0.8-2.5; substratum, 0.05-0.2 |
| Buckley clay loam<br>Buckley silt loam<br>Buckley loam<br>Buckley-Enumclaw loams *<br>(*see Enumclaw loam) | SM<br>SM-SC | A-1, A-2<br>A-2 | Fair | Good to poor | Not suitable | Fair to good | Susceptibility to frost action: slight to high. Shearing strength: high to mod. Load carrying capacity: high, except when wet. Shrink-swell potential: lot to mod. Substrata consists of dense(cemented) glacial clay mudflow material. Subject to high water. May become "quick" when saturated.<br>Permeability: subsoil, 0.8-2.5; substrata, 0.05-0.2 |
| Cagey sandy loam<br>Cagey gravelly loam<br>Cagey silt loam<br>Cagey silt loam - Norma silty clay loam complex | SM<br>SW-SP | A-2<br>A-1, A-3 | Fair | Poor | Poor | Good | Susceptibility to frost action: slight. Shearing strength: mod. to high. Load carrying capacity: high. Shrink-swell potential: low. May be subject to seasonal water table and seep areas. Substrata at 4 to 6 feet cemented sandy glacial till.<br>Permeability: subsoil, 2.5-5.0; substrata, less than 0.05 |
| Cagey fine sandy loam<br>Cagey gravelly sandy loam | SM-SC<br>CL | A-4<br>A-6 | Fair | Poor to not suitable | Very poor to not suitable | Good subsoils very poor substrata | Susceptibility to frost action: moderate to high. Shearing strength: high to moderate. Load carrying capacity: high to moderate. May be subject to seasonal water table and seep areas. Substrata at 4 to 6 feet cemented sandy glacial till.<br>Permeability: subsoil, 2.5-5.0; substrata, less than 0.05 |
| Camas clay loam | CL<br>SP | A-6<br>A-2 | Very poor | Very poor | Good to poor | Good | Susceptibility to frost action: slight to high. Shearing strength: Moderate. Load carrying capacity: low to high depending upon moisture content. Shrink-swell potential: low May be subject to periodic overflow.<br>Permeability: subsoil, 0.2-0.8; substratum, 5.0-10.0 |

Table 15. Soil features affecting engineering practices on highways, Puget Sound Area (con.)

| Soil Series and Type | Engineering Classification | | Suitability as Source of | | | | Highway Location and Trafficability |
|---|---|---|---|---|---|---|---|
| | Unified | AASHO | Topsoil | Sand | Gravel | Roadfill | |
| Camas gravelly loam | ML-CL<br>SP | A-4-6<br>A-2 | Not suitable | Very poor | Excellent to good | Good | Susceptibility to frost action: slight. Shearing strength: very high to moderate. Load carrying capacity: high. Shrink-swell potential: low. May be subject to periodic overflow. Permeability: subsoil, 0.2-0.8; substratum, 5.0-10.0 |
| Carbondale muck | PT | A-8 | Good | Not suitable | Not suitable | Not suitable | Low volume weight. Low strength. Shearing strength: very low. Load carrying capacity: very low. Generally, the soil moisture situation makes these soils very poorly suited as foundations or as a structural material in any of these uses. Subject shrinking and settling. High water table. Permeability, moderate to slow. |
| Carbondale muck, shallow | PT<br>variable | A-8<br>variable | Good | Not suitable | Not suitable | Not suitable | Organic surface not suited as above. Subsoil and substratum: susceptibility to frost action: low to high. Shearing strength: very low. Load carrying capacity: very low. Shrink-swell potential high to low. Subject to high water table. Permeability: 0.05-2.5. |
| Carlsborg gravelly loam<br>Carlsborg gravelly sandy loam | SM<br>SM-GM | A-1<br>A-2 | Fair | Poor | Poor to good | Good | Susceptibility to frost action: slight. Shearing strength: high to mod. Load carrying capacity: high. Shrink-swell potential: low Permeability: subsoil, 2.5-5.0; substrata, 2.5-5.0 |
| Carstairs gravelly loam | GM-GW<br>GW | A-1 | Not suitable | Very poor | Excellent | Good | Susceptibility to frost action: none. Shearing strength: very high to mod. Load carrying capacity: high. Shrink-swell potential: low Permeability: subsoil, 5.0-10.0; substratum, 5.0-10.0 |
| Casey fine sandy loam | SM<br>ML | A-2, A-4<br>A-7, A-2 | Surface, fair | Poor | Not suitable | Fair | Susceptibility to frost action: moderate to very high. Shearing strength: high to moderate. Load carrying capacity: low. Shrink-swell potential: low. May be subject to seasonal water table and seep spots. Permeability: subsoil, less than 0.05; substratum, 2.5-5.0. |
| Casey loam<br>Casey silt Loam | CH<br>CH-SM | A-7<br>A-7, A-4 | Fair | Not suitable | Not suitable | Not suitable | Susceptibility to frost action: moderate to high. Shearing strength: very low to low. Load carrying capacity: high, except when wet. Shrink-swell potential: high. May be subject to seasonal water table and seep spots. May become "quick" when wet. Permeability: subsoil, less than 0.05; substrata, less than 0.05 |
| Cathcart loam<br>Cathcart grav. loam<br>Cathcart grav. silt loam<br>Cathcart stony loam<br>Cathcart fine sandy loam | SM<br>GC | A-4<br>A-1 | Fair | Poor | Not suitable | Good | Susceptibility to frost action: moderate to high. Shearing strength: mod. to high. Shrink-swell potential: low Sandstone bedrock at 24.0-60.0 inches. Permeability: subsoil, 0.8-2.5; substrata, 0.05-0.2 |
| Chehalis loam<br>Chehalis silt loam | SM<br>SM | A-6<br>A-2-6 | Good | Not suitable | Not suitable | Good | Susceptibility to frost action: high. Shearing streng.mod. to high. Load carrying capacity: high. Shrink-swell potential: low May be subject to flooding. Permeability: subsoil, 0.8-2.5; substrata, 0.8-2.5 |

Table 15. Soil features affecting engineering practices on highways, Puget Sound Area (con.)

| Soil Series and Type | Engineering Classification | | Suitability as Source of | | | | Highway Location and Trafficability |
|---|---|---|---|---|---|---|---|
| | Unified | AASHO | Topsoil | Sand | Gravel | Roadfill | |
| Chehalis silty clay loam, mottled | OH<br>CH | A-7-5<br>A-7-6 | Fair | Not suitable | Not suitable | Not suitable | Susceptibility to frost action: moderate. Shearing strength: very low. Load carrying capacity: low to moderate, depending upon moisture. Shrink-swell potential: high to moderate. May be subject to flooding.<br>Permeability: subsoil, 0.8-2.5; substratum, 0.8-2.5 |
| Chimacum gravelly sandy loam | SM<br>SM-SP | A-2<br>A-2, A-3 | Topsoil, fair. Subsoil not suitable | Good to poor | Poor | Good | Susceptibility to frost action: slight. Shearing strength: moderate to high. Load carrying capacity: high, except when dry. Shrink-swell potential: low.<br>Permeability: subsoil, 5.0-10.0; substratum, 5.0-10.0 |
| Chimacum gravelly loamy sand<br>Chimacum very gravelly loamy sand | SM<br>GM-SP | A-1<br>A-1, A-2 | Topsoil, fair Subsoil not suitable | Poor | Good | Good | Susceptibility to frost action: slight. Shearing strength: moderate to high. Load carrying capacity: high, low when very dry. Shrink-swell potential: low.<br>Permeability: subsoil, 5.0-10.0; substrata, 5.0-10.0 |
| Cinebar silt loam | ML<br>ML | A-6<br>A-7-6 | Good | Not suitable | Not suitable | Good | Susceptibility to frost action: moderate to high. Shearing strength: low to mod. Load carrying capacity: low. Shrink-swell potential: low.<br>Permeability: subsoil, 0.8-2.5; substratum, 0.05-0.2 |
| Cispus pumicy sandy loam | SP-SM<br>SM | A-1<br>A-2-4 | Very poor | Poor to fair | Not suitable | Good | Susceptibility to frost action: slight. Shearing strength: high to mod. Load carrying capacity: high; low when dry. Shrink-swell potential: low.<br>Permeability: subsoil, 2.5-5.0; substratum, 0.2-0.8 |
| Clackamas silty clay loam | CH<br>CH | A-7-6<br>A-7-6 | Poor | Not suitable | Not suitable | Not suitable | Susceptibility to frost action: moderate to high. Shearing strength: very low. Load carrying capacity: high; low when wet. Shrink-swell potential: high. Subject to seasonal water table.<br>Permeability: subsoil, less than 0.05; substratum, 0.05-0.2 |
| Clallam gravelly loam<br>Clallam loam | SM<br>SM | A-2<br>A-2 | Fair | Not suitable | Not suitable | Good to fair | Susceptibility to frost action: high. Shearing strength: moderate to high. Load carrying capacity: high, except when wet. Shrink-swell potential: low to moderate. May be subject to seasonal water table and seep areas. May become "quick" when wet.<br>Permeability: subsoil, 0.2-0.8; substrata, less than 0.05 |
| Clallam gravelly sandy loam | SM<br>SC-SM | A-2<br>A-4, A-2 | Fair | Not suitable | Not suitable | Good | Susceptibility to frost action: moderate to high. Shearing strength: moderate to high, except when wet. Load carrying capacity: high, except when wet. May be subject to seasonal water table and seep areas. May become "quick" when wet. Shrink-swell potential: low.<br>Permeability: subsoil, 0.2-0.8; substratum, less than 0.05. |
| Clipper silty clay loam | SM<br>SP | A-2<br>A-1 | Poor | Good to fair | Not suitable | Good | Susceptibility to frost action: slight. Shearing strength: high to moderate. Load carrying capacity: high, except when wet. Subject to water table. Shrink-swell potential: moderate to low.<br>Permeability: subsoil, less than 0.05; substratum, 0.05-0.2 |

Table 15. Soil features affecting engineering practices on highways, Puget Sound Area (con.)

| Soil Series and Type | Engineering Classification | | Suitability as Source of | | | | Highway Location and Trafficability |
|---|---|---|---|---|---|---|---|
| | Unified | AASHO | Topsoil | Sand | Gravel | Roadfill | |
| Cloquallum silt loam | CL<br>ML-CL | A-6<br>A-4,A-6 | Fair to good | Not suitable | Not suitable | Poor to fair | Susceptibility to frost action: moderate to high. Shearing strength: low to moderate. Load carrying capacity: moderate, except when wet. Seasonal high water table. Shrink-swell potential: moderate. Permeability: subsoil, 0.2-0.8; substratum, 0.05-0.2 |
| Cloquallum silt loam, shallow over till | CL<br>SM-GM | A-6<br>A-2 | Fair to not suitable | Not suitable | Not suitable | Good to poor | Susceptibility to frost action: subsoil, moderate; substratum, slight. Shearing strength: moderate to very low. Load carrying capacity: moderate to high, except when wet. Shrink-swell potential: moderate to low. Seasonal high water table. Permeability: subsoil, 0.2-0.8; substratum, 0.05-0.2 |
| Coastal beach | SP<br>SP | A-2<br>A-2 | Not suitable | Fair to poor (salty) | Not suitable | Good | Susceptibility to frost action: none. Shearing strength: high Load carrying capacity: high, except when dry. Shrink-swell potential: low. Permeability: subsoil, 5.0-10.0; substratum, 5.0-10.0 |
| Cokedale loam<br>Cokedale silt loam | ML<br>ML | A-4<br>A-4 | Good | Not suitable | Not suitable | Fair | Susceptibility to frost action: moderate to very high. Shearing strength: low to mod. Shrink-swell potential: low. Subj. to flooding. Permeability: subsoil, 0.05-0.2; substrata, variable 0.05-2.5 |
| Cokedale sandy loam<br>Cokedale silt loam/Puyallup<br>Cokedale silty clay loam<br>Cokedale silty clay loam over Puyallup | ML<br>SM-SW | A-4,A-7<br>A-2,A-3 | Subsoil, good, substrata poor | Not suitable | Not suitable | Good to fair | Susceptibility to frost action: none to very high. Shearing strength: low to high. Load carrying capacity: high to low. Shrink-swell potential: moderate to low. Subject to flooding. Permeability: subsoil, 0.05-0.2; substrata, variable 0.05-2.5 |
| Corkindale loam | ML<br>SM | A-4<br>A-2 | Good | Fair | Fair to poor | Good | Susceptibility to frost action: slight. Shearing strength: low to mod. Load carrying capacity: high. Shrink-swell potential: low. Permeability: subsoil, 0.8-2.5; substratum, 5.0-10.0 |
| Colvos fine sandy loam | SM<br>SM | A-2<br>A-2 | Good | Poor | Very poor | Good | Susceptibility to frost action: moderate. Shearing strength: moderate to high. Load carrying capacity: high; may be low when dry. Shrink-swell potential: low. Seasonal high water table. Permeability: subsoil, 0.8-2.5; substratum, 0.05-0.2 |
| Colvos fine sandy loam over Everett grav. sandy loam complex | SM<br>SM-GM | A-4<br>A-1,A-4 | Fair to poor | Poor | Very poor to fair | Good | Susceptibility to frost action: moderate. Shearing strength: mod. to high. Load carrying capacity: high; may be low when dry. Shrink-swell potential: low Permeability: subsoil, 0.8-2.5; substrata, 0.05-0.2 |
| Colvos fine sandy loam over Kitsap silt loam - complex | SM or ML<br>ML-SM | A-4<br>A-4,A-6 | Fair to good | Not suitable | Not suitable | Good to fair | Susceptibility to frost action: moderate to high. Shearing strength: low to moderate. Load carrying capacity: high to low. Shrink-swell potential: moderate to high. Subject to slides. May be become "quick" when wet. Water may be under hydrostatic pressure on lower slopes. Permeability: subsoil, 0.8-2.5; substrata, 0.05-0.2 |

Table 15. Soil features affecting engineering practices on highways, Puget Sound Area (con.)

| Soil Series and Type | Engineering Classification | | Suitability as Source of | | | | Highway Location and Trafficability |
|---|---|---|---|---|---|---|---|
| | Unified | AASHO | Topsoil | Sand | Gravel | Roadfill | |
| Coupeville loam ** <br> Coupeville silt loam * | SC <br> CH <br> CL <br> CL | A-2 <br> A-7 <br> A-6 <br> A-7 | Fair | Not suitable | Not suitable | Fair ** to poor * | Susceptibility to frost action: moderate to high. Shearing strength: low to moderate. Load carrying capacity: high to moderate. May be low when wet. Shrink-swell potential: low to moderate. <br> Permeability: subsoil, 0.2-0.8; substrata, 0.05-0.2 |
| Coveland grav. loam <br> Coveland grav. silt loam | SM-ML <br> CL-CH | A-1, A-4 <br> A-6, A-7 | Fair | Not suitable | Not suitable | Fair to very poor | Susceptibility to frost action: high. Shearing strength: low to moderate. Load carrying capacity: high, except when wet. Shrink-swell potential: moderate to high. Subject to seasonal water table. May become "quick" when wet. <br> Permeability: subsoil, 0.05-0.2; substrata, less than 0.05 |
| Coveland silt loam | SM <br> SM-SC | A-2 <br> A-2 | Good to fair | Not suitable | Not suitable | Fair to good | Susceptibility to frost action: high. Shearing strength: moderate to high. Load carrying capacity: high when dry. Low when wet. Subject to seasonal water table. Shrink-swell potential: moderate. <br> Permeability: subsoil, 0.05-0.2; substratum, less than 0.05 |
| Coveland loam | SM <br> SM-CL | A-2 <br> A-7, A-2 | Good to fair | Not suitable | Not suitable | Fair to poor | Susceptibility to frost action: high. Shearing strength: high to moderate. Load carrying capacity: high when dry, low when wet. Shrink-swell potential: high to moderate. Subject to seasonal water table. May become "quick" when wet. <br> Permeability: subsoil, 0.05-0.2; substratum, less than 0.05 |
| Coveland stony silt loam | SM-SC <br> CH | A-4 <br> A-7 | Fair to poor | Not suitable | Not suitable | Not suitable to fair | Susceptibility to frost action: high. Shearing strength: very low to high. Load carrying capacity: high, except when wet. Shrink-swell potential: high to moderate. <br> Permeability: subsoil, 0.05-0.2; substratum, less than 0.05 |
| Crescent gravelly loam | GM <br> GM | A-4, A-6 <br> A-4, A-6 | Not suitable | Not suitable | Not suitable | Good | Susceptibility to frost action: slight. Shearing strength: mod to high. Load carrying capacity: high. Shrink-swell potential: low. <br> Permeability: subsoil, 2.5-5.0; substratum, 5.0-10.0 |
| Custer sandy loam <br> Custer fine sandy loam <br> ---------- <br> Custer silt loam | SM-SP <br> SM-SM <br> ---------- <br> SM <br> SM-SP | A-3 <br> A-3, A-2 <br> ---------- <br> A-2 <br> A-3, A-2 | Fair | Good | Not suitable | Good | Susceptibility to frost action: slight. Shearing strength: medium to high. Load carrying capacity: high. Shrink-swell potential: low. High water table. May be come "quick" when wet. <br> Permeability: subsoil, 0.05-0.2; substrata, 0.05-0.2 |
| Dabob very gravelly sandy loam | GM-SM <br> SM-SP | A-2 <br> A-1 | Not suitable | Poor | Fair | Good | Susceptibility to frost action: slight. Shearing strength: moderate to high. Load carrying capacity: high. Shrink-swell potential: low. Cemented substratum at 2 to 2-1/2 feet. Seasonal high water table. <br> Permeability: subsoil, 2.5-5.0; substratum, 0.05-0.2 |

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| Soil Series and Type | Engineering Classification | | Suitability as Source of | | | | Highway Location and Trafficability |
|---|---|---|---|---|---|---|---|
| | Unified | AASHO | Topsoil | Sand | Gravel | Roadfill | |
| Delphi gravelly loam | GM<br>SM-GM | A-1, A-2<br>A-2 | Poor | Not suitable | Poor | Good | Susceptibility to frost action: moderate. Shearing strength: moderate to high. Load carrying capacity: high, except when wet. Shrink-swell potential: low. Lower slopes may be subject to seasonal water table and seep spots.<br>Permeability: subsoil, 0.2-0.8; substratum, 0.05-0.2 |
| Dick loamy fine sand<br>Dick loamy sand<br>Dick sandy loam | SM<br>SM | A-2<br>A-2 | Fair | Fair | Not suitable | Good | Susceptibility to frost action: slight. Shearing strength: mod. to high. Load carrying capacity: high, except when dry.<br>Shrink-swell potential: low<br>Permeability: subsoil, 5.0-10.0; substrata, 5.0-10.0 |
| Dick loamy sand/Chimacum grav. loamy sand complex | SP-GP<br>SP-GP | A-3, A-1<br>A-3, A-1 | Poor | Fair to poor | Not suitable to excellent | Good | |
| Discovery Bay grav. sandy loam<br>Discovery Bay very grav. sandy loam<br>Discovery Bay grav. sandy loam/Alderwood<br>Discovery Bay grav. sandy loam/Hoodsport<br>Discovery Bay/Rock outcrop | GM-GP<br>GM-GP | A-1<br>A-1 | Not suitable | Not suitable | Poor | Good | Susceptibility to frost action: slight. Shearing strength: moderate to high. Load carrying capacity: high.<br>Shrink-swell potential: low. Basalt bedrock at 30 to 50 inches.<br>Permeability: subsoil, 2.5-5.0; substrata, 0.8-2.5 |
| Dungeness loam<br>Dungeness silt loam | ML-SM<br>SM | A-4<br>A-1 | Good to fair | Poor | Not suitable | Fair to good | Susceptibility to frost action: moderate. Shearing strength: low to moderate. Load carrying capacity: low. Shrink-swell potential: low. May be subject to overflow.<br>Permeability: subsoil, 0.8-2.5; substrata, 5.0-10.0 |
| Dungeness fine sandy loam<br>Dungeness fine sandy loam, shallow | SM<br>SM | A-1<br>A-1 | Fair | Very poor | Not suitable | Good | Susceptibility to frost action: slight. Shearing strength: moderate to high. Load carrying capacity: high. Subject to periodic overflow.<br>Shrink-swell potential: low.<br>Permeability: subsoil, 0.8-2.5; substrata, 5.0-10.0 |
| Dupont muck | SM<br>SM | A-2<br>A-2, A-1 | Surface, fair. Subsoil&substratum not suitable | Not suitable | Not suitable | Not suitable | Shearing strength: mod. to high. Load carrying capacity: very low. The soil moisture situation makes these soils very poorly suited as foundations or as structural material for highways.<br>High water table.<br>Permeability: subsoil, 0.2-0.8; substratum, 0.05-0.2 |
| Ebeys sandy loam | SM<br>SP | A-4<br>A-3 | Fair to very poor | Good | Not suitable | Good | Susceptibility to frost action: slight. Shearing strength: high to very high. Load carrying capacity: high, except when dry. Shrink-swell potential: low. May have wet areas.<br>Permeability: subsoil, 0.8-2.5; substratum, 5.0-10.0 |

Table 15. Soil features affecting engineering practices on highways, Puget Sound Area (con.)

| Soil Series and Type | Engineering Classification | | Suitability as Source of | | | | Highway Location and Trafficability |
|---|---|---|---|---|---|---|---|
| | Unified | AASHO | Topsoil | Sand | Gravel | Roadfill | |
| Edgewick fine sandy loam<br>Edgewick silt loam<br>Edgewick very fine sandy loam<br>Edgewick sand | SM-ML<br>GW | A-2, A-4<br>A-1 | Fair | Very poor | Excellent to poor | Good | Susceptibility to frost action: slight to moderate. Shearing strength: mod. to high. Load carrying capacity: high. Shrink-swell potential: low. Subject to periodic overflow.<br>Permeability: subsoil, 0.8-2.5; substrata, 5.0-10.0 |
| Edmonds sandy loam<br>Edmonds silt loam<br>Edmonds loam<br>Edmonds/Tromp silt loams | SM<br>SP-SM | A-2<br>A-2, A-3 | Fair to good | Good | Poor | Good | Susceptibility to frost action: slight. Shearing strength: moderate to high. Load carrying capacity: high,except when wet. Shrink-swell potential: low. May become "quick" when wet.<br>Permeability: subsoil, variable 0.05-5.0; substrata, 0.05-0.2 |
| Edmonds fine sandy loam | SM<br>SM | A-2<br>A-2, A-1 | | | | | |
| Eld loam<br>Eld silt loam<br>Eld silty clay loam<br>Eld gravelly loam | SM-ML<br>SM-ML | A-2, A-4<br>A-1 | Fair to good | Not suitable | Not suitable | Fair to good | Susceptibility to frost action: moderate to high. Shearing strength low to high. Load carrying capacity: high; low when wet. Shrink-swell potential: low. May become "quick" when wet.<br>Permeability: subsoil, 0.2-0.8; substrata, 0.2-0.8 |
| Elwha loam | ML-CL<br>ML-CL | A-4, A-6<br>A-6, A-7 | Fair | Not suitable | Not suitable | Poor | Susceptibility to frost action: high. Shearing strength: low to mod. Load carrying capacity: moderate to low. Shrink-swell potential: moderate. May become "quick" when wet.<br>Permeability: subsoil, 0.05-0.2; substratum, less than 0.05 |
| Enumclaw loam | SM<br>SM | A-2<br>A-1 | Fair | Not suitable | Not suitable | Good | Susceptibility to frost action: moderate to high. Shearing strength: mod. to high. Load carrying capacity: high. Shrink-swell potential: low. Dense, cemented glacial mudflow substrata. Subject to seasonal water table. May become "quick" when wet.<br>Permeability: subsoil, 0.2-0.8; substrata, 0.05-0.2 |
| Enumclaw fine sandy loam<br>Enumclaw grav. sandy loam | SM<br>SM | A-1<br>A-1, A-2 | | | | | |
| Everett grav. sandy loam<br>Everett grav. loamy sand<br>Everett stony sandy loam<br>Everett stony loamy sand | GW<br>GW-GM | A-1<br>A-1 | Not suitable | Not suitable | Excellent | Good | Susceptibility to frost action: none. Shearing strength: very high. Load carrying capacity: high. Shrink-swell potential: low.<br>Permeability: subsoil, 5.0-10.0; substrata, 5.0-10.0 |
| Everett gravelly loam | SM-ML<br>GM-GW | A-4<br>A-1 | Fair to poor | Not suitable | Good | Good | Susceptibility to frost action: slight.Shearing strength:mod to very high. Load carrying capacity: high. Shrink-swell potential: low<br>Permeability: subsoil, 5.0-10.0; substratum, 5.0-10.0 |
| Everson silt loam | ML-CL<br>CL | A-4, A-6<br>A-4 | Good | Not suitable | Not suitable | Poor | Susceptibility to frost action: high. Shearing strength: mod. to low. Load carrying capacity: moderate. Shrink-swell potential: high to moderate. May become "quick" when wet.<br>Permeability: subsoil, less than 0.05; substrata,0.2-0.8 |
| Everson fine sandy loam<br>Everson clay loam | ML<br>CL | A-4, A-6<br>A-2 | | | | | |

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| Soil Series and Type | Engineering Classification | | Suitability as Source of | | | | Highway Location and Trafficability |
|---|---|---|---|---|---|---|---|
| | Unified | AASHO | Topsoil | Sand | Gravel | Roadfill | |
| Fidalgo rocky loam | SM-ML<br>Serpentine bedrock | A-4 | Fair | Not suitable | Not suitable | Fair | Susceptibility to frost action: moderate. Shearing strength: low to moderate. Load carrying capacity: high. Serpentine bedrock at less than 1 foot to more than 2 feet. Shrink-swell potential: low. May become "quick" when wet.<br>Permeability: subsoil, 0.8-2.5; substratum, less than 0.05 |
| Fitch gravelly sandy loam | GW<br>GW-GM | A-1<br>A-1 | Not suitable | Not suitable | Excellent | Good | Susceptibility to frost action: none. Shearing strength: very high. Load carrying capacity: high. Shrink-swell potential: low<br>Permeability: subsoil, 5.0-10.0; substratum, 5.0-10.0 |
| Fresh water marsh | | | Good | Not suitable | Not suitable | Not suitable | Low volume weight. Low strength. Generally, the soil-moisture situation makes these soils poorly suited as foundations or as structural material. |
| Giles loam<br>Giles silt loam<br>Giles silt loam, grav.subsoil<br>Giles-Tromp silt loams, complex | ML<br>ML-CL | A-7<br>A-4, A-6 | Good | Not suitable | Not suitable | Fair | Susceptibility to frost action: moderate. Shearing strength: low to mod. Load carrying capacity: moderate to low, depending upon moisture. Shrink-swell potential: moderate.<br>Permeability: subsoil, 0.2-0.8; substrata, 0.8-2.5 |
| Giles fine sandy loam | SM<br>SM | A-2<br>A-2, A-3 | Good | Not suitable | Not suitable | Good to fair | Susceptibility to frost action: slight. Shearing strength: mod. to high Load carrying capacity: moderate to low, depending upon moisture. Shrink-swell potential: moderate<br>Permeability: subsoil, 0.2-0.8; substratum, 0.8-2.5 |
| Gilligan loam<br>Gilligan silt loam | ML<br>SM-SP | A-4<br>A-2 | Fair | Poor | Poor | Fair (Schist) | Susceptibility to frost action: moderate. Shearing strength: low to high. Load carrying capacity: moderate. Shrink-swell potential: low.<br>Permeability: subsoil, 0.2-0.8; substrata, 0.8-2.5 |
| Gilligan gravelly loam | GM<br>SM-ML | A-2<br>A-4, A-5 | Very poor | Poor | Poor | Fair (Schist) | Susceptibility to frost action: moderate. Shearing strength: mod. to high. Load carrying capacity: moderate. Shrink-swell potential: low.<br>Permeability: subsoil, 0.2-0.8; substratum, 0.8-2.5 low. |
| Gravel pits | GW | A-1 | Very poor | Poor | Excellent | Excellent | Susceptibility to frost action: none. Shearing strength: very high. Load carrying capacity: high. Shrink-swell potential: low.<br>Permeability: substratum, over 10.0 |
| Greenwater sand<br>Greenwater loamy sand | SM-SP<br>SM-SP | A-2<br>A-2 | Poor | Good | Poor | Good | Susceptibility to frost action: slight. Shearing strength: high to mod. Load carrying capacity: high. Shrink-swell potential: low.<br>Permeability: subsoil, 5.0-10.0; substrata, 5.0-10.0 |
| Greenwater sandy loam | SW<br>SW | A-3<br>A-3 | Fair | Good | Poor | Good | |
| Greenwood peat | Pt | A-8 | Not suitable | Not suitable | Not suitable | Not suitable | Not suitable. Low volume weight and settling. Not suited as foundations or fill material. High water table. |

Table 15. Soil features affecting engineering practices on highways. Puget Sound Area (con.)

| Soil Series and Type | Engineering Classification | | Suitability as Source of | | | | Highway Location and Trafficability |
|---|---|---|---|---|---|---|---|
| | Unified | AASHO | Topsoil | Sand | Gravel | Roadfill | |
| Grove gravelly loam | SM-ML<br>GM-GW | A-4<br>A-1 | Fair to very poor | Poor | Good | Good | Susceptibility to frost action: slight. Shearing strength: moderate to very high. Load carrying capacity: high. Shrink-swell potential: low. |
| Grove gravelly sandy loam | GW<br>GW-GM | A-1<br>A-1 | Not suitable | Very poor | Excellent | Good | |
| Grove stony sandy loam | SM<br>GM-SM | A-1<br>A-1 | Fair to very poor | Poor | Good | Good | Permeability: subsoil, 2.5-5.0; substrata; 5.0-10.0 |
| Grove cobbly sandy loam<br>Grove very grav. sandy loam | GW<br>SP | A-1<br>A-2 | Very poor | Poor | Fair to good | Good | |
| Hale silt loam<br>Hale-Norma silt loams | ML<br>SM | A-4, A-5<br>A-2 | Good | Fair | Not suitable | Good | Susceptibility to frost action: high. Shearing strength: high. Load carrying capacity: low. Shrink-swell potential: low Permeability: subsoil, 2.5-5.0; substrata, less than 0.05 |
| Harstine grav. sandy loam | SM<br>SM | A-2<br>A-2 | Fair | Poor | Poor | Good | Susceptibility to frost action: slight. Shearing strength: moderate to high. Load carrying capacity: high, except when dry. Cemented glacial till substratum. May have seasonal water table and seep areas. Shrink-swell potential: low.<br>Permeability: subsoil, 0.8-2.5; substratum, 0.05-0.2 |
| Heisler gravelly loam<br>Heisler shaly loam<br>Heisler stony loam | SM<br>SM-SC | A-2<br>A-2, A-4 | Fair | Poor | Poor | Good | Susceptibility to frost action: moderate. Shearing strength: mod. to high. Load carrying capacity: high. Shrink-swell potential: low<br>Permeability: subsoil, 0.2-0.8; substrata, 0.05-0.2 |
| Hemmi silt loam | CH<br>SP | A-6, A-7<br>A-3 | Fair | Good | Not suitable | Sub-stratum, good | Susceptibility to frost action: moderate to slight. Shearing strength: low to high. Load carrying capacity: high, when dry. Shrink-swell potential: high to low. High water table.<br>Permeability: subsoil, less than 0.05; substratum, 2.5-5.0 |
| Hoodsport grav. sandy loam | GM<br>GM-GP | A-1<br>A-1 | Very poor | Not suitable | Fair to poor. Cemented | Good | Susceptibility to frost action: slight. Shearing strength: very high to mod. Load carrying capacity: high. Shrink-swell potential: low. Cemented very gravelly sands. May be subject to seasonal water table and seep areas.<br>Permeability: subsoil, 2.5-5.0; substrata, less than 0.05 |
| Hoodsport stony sandy loam | SM-GM<br>SM-GM | A-2, A-1<br>A-2, A-1 | | | | | |
| Hoodsport very grav. sandy loam and gravelly loam | GM-GP<br>GM-GP | A-1<br>A-1 | | | | | |
| Hovde gravelly sandy loam | SM<br>SM-SP | A-4<br>A-2 | Fair | Poor | Not suitable | Good | |
| Hovde loamy sand<br>Hovde silty clay loam | GP-SP<br>SP | A-1<br>A-3 | Not suitable | Very poor | Not suitable | Good | Susceptibility to frost action: slight. Shearing strength: high to moderate, depending upon drainage. |
| Hovde sand | SP<br>SP | A-1<br>A-1 | Very poor | Fair | Not suitable | Good | Shrink-swell potential: low. High water table. Becomes "quick" when saturated. May be salty. |
| Hovde loam | GM-SM<br>SP-SM | A-1<br>A-3 | Fair | Very poor | Not suitable | Good | Permeability: subsoil, 0.2-0.8; substrata, 5.0-10.0 |

Table 15. Soil features affecting engineering practices on highways, Puget Sound Area (con.)

| Soil Series and Type | Engineering Classification | | Suitability as Source of | | | | Highway Location and Trafficability |
|---|---|---|---|---|---|---|---|
| | Unified | AASHO | Topsoil | Sand | Gravel | Roadfill | |
| Hoypus coarse sandy loam | GW-SW<br>GW-SW | A-1<br>A-1 | Not suitable | Very poor | Excellent | Good | Susceptibility to frost action: none. Shearing strength: very high. Load carrying capacity: high. Shrink-swell potential: low Permeability: subsoil, 5.0-10.0; substrata, 5.0-10.0 |
| Hoypus grav. loamy sand | SM<br>GW-GM | A-2<br>A-1, A-2 | Not suitable | Poor | Good to excellent | Good | |
| Indianola fine sandy loam<br>Indianola sandy loam<br>Indianola loamy fine sand<br>Indianola loamy sand | SM-SP<br>SM-SP | A-1<br>A-3 | Fair | Good | Not suitable | Good | Susceptibility to frost action: slight. Shearing strength: moderate to high. Load carrying capacity: high, except when dry. Shrink-swell potential: low. Permeability: subsoil, 2.5-5.0; substrata, 5.0-10.0 |
| Indianola loam<br>Indianola sandy loam - Roche loam complex | SM-SP<br>SM-SP | A-1<br>A-3 | Good to fair | Good | Not suitable | Good | |
| Indianola silt loam | ML-SM<br>SM | A-4, A-2<br>A-2 | Good to fair | Good to poor | Not suitable | Good | Susceptibility to frost action: moderate to slight. Shearing strength: moderate to high. Load carrying capacity: high, when moist. Low when dry. Shrink-swell potential: low Permeability: subsoil, 2.5-5.0; substratum, 5.0-10.0 |
| Issaquah silt loam | ML<br>MH-ML | A-5<br>A-4, A-7 | Good | Not suitable | Not suitable | Poor to not suitable | Susceptibility to frost action: very high. Shearing strength: Very low to moderate. Load carrying capacity: low. Shrink-swell potential: high. May become "quick" when wet. Permeability: subsoil, 0.05-0.2; substratum, less than 0.05 |
| Juno gravelly sandy loam<br>Juno loamy sand | SM<br>SM | A-4<br>A-4, A-2 | Fair to poor | Poor | Very poor | Good | Susceptibility to frost action: slight. Shearing strength: moderate to high. Load carrying capacity: high, except when dry. Shrink-swell potential: low. Subject to flooding. Permeability: subsoil, 5.0-10.0; substrata, more than 10.0 |
| Juno sandy loam | SP<br>SP | A-1<br>A-1 | Fair to very poor | Poor | Very poor | Good | |
| Juno loam | SP-SM<br>SP | A-1, A-3<br>A-1, A-3 | | | | | |
| Kapowsin gravelly clay loam | SC<br>SM | A-2<br>A-4 | Fair | Not suitable | Not suitable | Fair to good | Susceptibility to frost action: high. Shearing strength: moderate to high. Load carrying capacity: high, except when wet. Shrink-swell potential: low to moderate. Subject to seasonal water table. May become "quick" when saturated. Permeability: subsoil, 0.2-0.8; substrata, 0.05-0.2 |
| Kapowsin gravelly sandy loam | SM-SC<br>SM | A-2<br>A-4 | | | | | |
| Kapowsin gravelly loam | SM<br>SM | A-4<br>A-4 | | | | | |
| Keystone fine sandy loam<br>Keystone loamy sand | SM<br>SP-SM | A-2<br>A-2, A-3 | Fair to poor | Good | Not suitable | Good | Susceptibility to frost action: slight. Shearing strength: moderate. May range low to high. Load carrying capacity: high, except when dry. Shrink-swell potential: low Permeability: subsoil, 5.0-10.0; substrata, 5.0-10.0 |

Table 15. Soil features affecting engineering practices on highways, Puget Sound Area (con.)

| Soil Series and Type | Engineering Classification | | Suitability as Source of | | | | Highway Location and Trafficability |
|---|---|---|---|---|---|---|---|
| | Unified | AASHO | Topsoil | Sand | Gravel | Roadfill | |
| Kickerville silt loam | GM<br>GP | A-2<br>A-1 | Surface good. Subsoil not suitable | Poor | Good | Good | Susceptibility to frost action: slight. Shearing strength: high to moderate. Load carrying capacity: high. Shrink-swell potential: low. Underlain by dense, stony clay till at 8 to 12 feet. May have water table and seep areas.<br>Permeability: subsoil, 2.5-5.0; substratum, 5.0-10.0 |
| Kitsap silt loam<br>Kitsap loam<br>Kitsap silty clay loam<br>Kitsap-Indianola complex | ML<br>ML-CL | A-5<br>A-4, A-5 | Good | Not suitable | Not suitable | Poor | Susceptibility to frost action: very high. Shearing strength: very low to moderate. Load carrying capacity: moderate. Shrink-swell potential: moderate to high. May become "quick" when saturated.<br>Permeability: subsoil, 0.05-0.2; substrata, less than 0.05 |
| Kitsap gravelly loam | CL<br>CH | A-6<br>A-7 | Fair | Not suitable | Not suitable | Very poor | Underlain by laminated silts, fine sands, and clays. May be subject to seasonal water table and seep areas. Water may seep between laminated sands, silts and clays to lower lying areas.<br>These soils are extremely susceptible to slides. |
| Klaber silty clay loam | CH<br>CH | A-7-6<br>A-7-6 | Poor | Not suitable | Not suitable | Not suitable | Susceptibility to frost action: moderate. Shearing strength: very low. Load carrying capacity: high, except when wet. Shrink-swell potential: high. Subject to seasonal water table and flooding.<br>Permeability: subsoil, 0.05-0.2; substratum, less than 0.05 |
| Klaus gravelly loam<br>Klaus gravelly sandy loam<br>Klaus sandy loam | GM<br>GM-GW | A-2 | Very poor | Very poor | Very poor | Good | Susceptibility to frost action: slight. Shearing strength: moderate to very high. Load carrying capacity: high. Shrink-swell potential: low.<br>Permeability: subsoil, 2.5-5.0; substrata, 5.0-10.0 |
| Kline gravelly loam<br>Kline loam<br>Kline silt loam<br>Kline sandy loam | GW-GM<br>GP | A-2, A-4<br>A-1 | Surface good. Subsoils very poor | Very good | Not suited | Good | Susceptibility to frost action: slight. Shearing strength: very high to moderate. Load carrying capacity: high, except when saturated. May be subject to flooding. Shrink-swell potential: low.<br>Permeability: subsoil, 0.8-2.5; substrata, 2.5-5.0 |
| Koch gravelly loam<br>Koch gravelly sandy loam<br>Koch silt loam | SM<br>SP-SM | A-2<br>A-2, A-3 | Fair | Fair | Poor | Good | Susceptibility to frost action: slight. Shearing strength: high to mod. Load carrying capacity: high. Shrink-swell potential: low. Intermittent cemented sand and gravel. May be subject to seasonal water table and flooding. May become "quick" when saturated.<br>Permeability: subsoil, 0.2-0.8; substrata, 0.05-0.2 |
| Kopiah loam<br>Kopiah silt loam | CL<br>CH | A-7-6<br>A-7-6 | Fair | Not suitable | Not suitable | Very poor | Susceptibility to frost action: high. Shearing strength: very low to mod. Load carrying capacity: moderate. Low when wet. "clay-pan" substrata. Subject to high water table. May become "quick"<br>Permeability: subsoil, 0.2-0.8; substrata, less than 0.05 |
| Kopiah silty clay loam | SM<br>CL-SC | A-4<br>A-7, A-2 | | | | | |
| Labounty silt loam<br>Labounty-McKenna complex | CL<br>CL-CH | A-6<br>A-6 | Fair | Not suitable | Not suitable | Very poor | Susceptibility to frost action: high. Shearing strength: moderate to very low. Load carrying capacity: high, except when wet. Shrink-swell potential: high. Dense gravelly and stony glacial clay till at 3 to 4 feet. May have seasonal water table and seep.<br>Permeability: subsoil, 0.05-0.2; substrata, less than 0.05 |

Table 15. Soil features affecting engineering practices on highways, Puget Sound Area (con.)

| Soil Series and Type | Engineering Classification | | Suitability as Source of | | | | Highway Location and Trafficability |
|---|---|---|---|---|---|---|---|
| | Unified | AASHO | Topsoil | Sand | Gravel | Roadfill | |
| Lummi silty clay loam<br>Lummi silt loam | MH<br>MH-ML | A-7<br>A-7, A-4 | Fair | Not suitable | Not suitable | Not suitable | Susceptibility to frost action: high. Shearing strength: low Load carrying capacity: low. Shrink-swell potential: high. May be salty and subject to high water table from tides. Permeability: subsoil, 0.05-0.2; substrata, 0.05-0.2 |
| Lummi fine sandy loam | SW<br>SW | A-3<br>A-3, A-2 | Poor | Fair (May be saline) | Not suitable | Good | Susceptibility to frost action: moderate. Shearing strength: very high. Load carrying capacity: high, when moist. May become "quick" when saturated. Shrink-swell potential: very low. May be subject to water table from tides and be salty. Permeability: subsoil, 0.05-0.2; substratum, 0.05-0.2 |
| Lynden loamy sand | SP<br>SP | A-3, A-1<br>A-3, A-1 | Very poor | Excellent | Not suitable | Good | Susceptibility to frost action: none. Shearing strength: high. Load carrying capacity: high when moist. Low when dry. Shrink-swell potential: low. Permeability: subsoil, 2.5-5.0; substrata, 5.0-10.0 |
| Lynden sandy loam | SP<br>SP | A-3, A-1<br>A-3, A-1 | Poor | | | | |
| Lynden loam<br>Lynden gravelly loam | SM<br>SW | A-4<br>A-3 | Fair | Excellent | Very poor | Good | Susceptibility to frost action: none to slight. Shearing strength: very high to Load carrying capacity: high, except when dry. Shrink-swell potential: low Permeability: subsoil, 2.5-5.0; substrata, 5.0-10.0 |
| Lystair sandy loam<br>Lystair fine sandy loam<br>Lystair loamy sand | SM<br>SM | A-2, A-4<br>A-2 | Fair to poor | Fair | Not suitable | Good | Susceptibility to frost action: slight. Shearing strength: mod. to high. *Load carrying capacity: high. Shrink-swell potential: low* Permeability: subsoil, 5.0-10.0; substrata, 5.0-10.0 |
| Marblemount stony loam | GM<br>GP | A-2<br>A-1 | Fair | Poor | Not suitable | Good | Susceptibility to frost action: high. Shearing strength: high. Load carrying capacity: high. Shrink-swell potential: low. Granite bedrock at depths of 1 to 6 feet. Permeability: subsoil, 0.8-2.5; substratum, less than 0.05 |
| Maytown silt loam<br>Maytown fine sandy loam | ML-CL<br>SM | A-4, A-6<br>A-2, A-4 | Good | Not suitable | Not suitable | Fair to good | Susceptibility to frost action: high to moderate. Shearing strength: low to moderate. Load carrying capacity: high. Low when wet. May become "quick" when wet. Shrink-swell potential: low. Subject to periodic flooding and seasonal water table. Permeability: subsoil, 0.8-2.5; substrata, 0.05-0.2 |
| McKenna grav. clay loam<br>McKenna gravelly loam | SM<br>GP-GM | A-2<br>A-1 | Fair | Not suitable | Not suitable | Fair | Susceptibility to frost action: high. Shearing strength: mod. to high. Load carrying capacity: high, except when wet. Cemented stony sandy clay glacial till at 1-1/2 to 2 feet. Seasonal flooding and high water table. Shrink-swell potential: moderate. Permeability: subsoil, 0.2-0.8; substrata, less than 0.05. |
| McKenna silty clay loam<br>McKenna loam | MH<br>MH | A-7<br>A-7 | Good | Not suitable | Not suitable | Very poor | Susceptibility to frost action: high. Shearing strength: very low. Load carrying capacity: low. Subject to seasonal flooding and high water table. Shrink-swell potential: high. Permeability: subsoil, 0.2-0.8; substrata, less than 0.05 |

Table 15. Soil features affecting engineering practices on highways, Puget Sound Area (con.)

| Soil Series and Type | Engineering Classification | | Suitability as Source of | | | | Highway Location and Trafficability |
|---|---|---|---|---|---|---|---|
| | Unified | AASHO | Topsoil | Sand | Gravel | Roadfill | |
| McMurray (Rifle) peat<br>McMurray (Carbondale) muck<br>Mukilteo peat<br>Semiahmoo muck<br>Rifle peat | Pt<br>Pt | A-8<br>A-8 | Good | Not suitable | Not suitable | Not suitable | Not suitable for highway location. Shearing strength: very low. Load carrying capacity: very low. Subject to flooding and high water table, also shrinking and settling. Shrink-swell potential: Permeability: subsoil, Variable 0.02-5.0; substrata, 0.05-0.2 |
| McMurray peat, shallow<br>Mukilteo peat, shallow<br>Semiahmoo muck, shallow | Pt<br>CL-SM | A-8<br>A-7, A-2 | Good | Not suitable | Not suitable | Not suitable | Not suitable for highway location. Shearing strength: very low. Load carrying capacity: very low. Subject to shrinking and settling. Subject to seasonal flooding and high water table. Shrink-swell potential: high<br>Permeability: suboil, variable 0.2-5.0; substrata, 0.05-0.2 |
| Melbourne loam<br>Melbourne silty clay loam | CL<br>CH | A-7-6<br>A-7-6 | Fair | Not suitable | Not suitable | Poor to not suitable | Susceptibility to frost action: moderate to high. Shearing strength: very low. Load carrying capacity: moderate to low. Shale and clayey sandstone bedrock at 2 to 4 feet. Shrink-swell potential: high.<br>Permeability: subsoil, 0.2-0.8; substrata, 0.05-0.2 |
| Melbourne stony loam | CL<br>CH-GC | A-7-6<br>A-7-6 | | | | | |
| National Pumicy loam<br>National pumicy sandy loam | SM<br>SM | A-4<br>A-4 | Fair | Poor | Poor | Good | Susceptibility to frost action: high. Shearing strength: mod. to high Load carrying capacity: high. Shrink-swell potential: low.<br>Permeability: subsoil, 5.0-10.0; substrata, 0.2-0.8 |
| Neptune sandy loam<br>Neptune gravelly sandy loam | GW<br>GP | A-1<br>A-1 | Not suitable | Very poor | Shells-not suitable | Good | Susceptibility to frost action: none. Shearing strength: very high. Load carrying capacity: high. Shrink-swell potential: low.<br>Permeability: subsoil, 2.5-5.0; substrata, 5.0-10.0 |
| Nesika loam | SM<br>SM | A-5-1<br>A-1 | Fair to good | Very poor | Poor | Good | Susceptibility to frost action: moderate. Shearing strength: mod. to high. Load carrying capacity: high. May be subject to flooding. Shrink-swell potential: low.<br>Permeability: subsoil, 0.8-2.5; substrata, 2.5-5.0 |
| Nesika soils, undifferentiated | SM-GP<br>SM-GP | A-5-1<br>A-1 | | | | | |
| Newberg loam<br>Newberg silt loam | CH-MH<br>SM | A-7-6<br>A-4 | Good | Poor | Poor | Fair | Susceptibility to frost action: moderate to high. Shearing strength: very low to mod. Load carrying capacity: high, except when saturated. Shrink swell potential: low<br>Permeability: subsoil, 2.5-5.0; substrata, 5.0-10.0 |
| Newberg loamy sand<br>Newberg loamy fine sand | SM<br>SM | | Fair | Poor | Poor | Fair | Susceptibility to frost action: slight to moderate. Shearing strength: very low to high. Load carrying capacity: high to low. May be subject to flooding. Shrink-swell potential: low.<br>Permeability: subsoil, 2.5-5.0; substrata, 5.0-10.0 |
| Newberg sandy loam<br>Newberg fine sandy loam | ML-MH<br>SM | | | | | | |
| Nisqually sand<br>Nisqually loamy sand | SM<br>SP-SM | A-2<br>A-3 | Fair to poor | Good | Not suitable | Good | Susceptibility to frost action: slight to none. Shearing strength: mod. to high. Load carrying capacity: high. Shrink-swell potential: low.<br>Permeability: subsoil, 2.5-5.0; substrata, 5.0-10.0 |

Table 15. Soil features affecting engineering practices on highways. Puget Sound Area (con.)

| Soil Series and Type | Engineering Classification | | Suitability as Source of | | | | Highway Location and Trafficability |
|---|---|---|---|---|---|---|---|
| | Unified | AASHO | Topsoil | Sand | Gravel | Roadfill | |
| Nookachamps silty clay loam | ML<br>CL | A-4, A-6<br>A-6 | Fair to good | Not suitable | Not suitable | Very poor | Susceptibility to frost action: very high to high. Shearing strength: very low to moderate. Load carrying capacity: low. Subject to flooding and seasonal water table. May become "quick" when saturated. Shrink-swell potential: high.<br>Permeability: subsoil, 0.2-0.8; substrata, less than 0.05 |
| Nookachamps silt loam | ML<br>MH | A-7<br>A-7 | | | | | |
| Nooksack silt loam<br>Nooksack fine sandy loam | ML<br>MH | A-7<br>A-7 | Good | Not suitable | Not suitable | Fair to very poor | Susceptibility to frost action:high. Shearing strength: very low to mod. Load carrying capacity: low. May be subject to periodic flooding and become "quick" when saturated. Shrink-swell potential: high.<br>Permeability: subsoil, 0.2-0.8; substrata, 0.05-0.2 |
| Nordby loam | SM-SC<br>GM | A-4<br>A-2, A-4 | Fair | Poor | Poor | Good to fair | Susceptibility to frost action; moderate. Shearing strength: mod.to high. Load carrying capacity: high. Substratum may be sporadically cemented. Shrink-swell potential: low.<br>Permeability: subsoil, 0.2-0.8; substrata, 0.05-0.2 |
| Norma loam<br>Norma fine sandy loam | MH-GM<br>SM | A-2<br>A-2 | Fair | Poor | Not suitable | Very poor | Susceptibility to frost action: moderate to high. Shearing strength: low to high. Load carrying capacity: high. Subject to high water table and flooding. May become "quick" when saturated. Shrink-swell potential: low.<br>Permeability: subsoil, 0.05-2.5; substrata, variable 0.05-2.5 |
| Norma clay loam<br>Norma silty clay loam | SM<br>SM-ML | A-1, A-2<br>A-2, A-4 | Good | Poor | Not suitable | Very poor | |
| Norma silt loam<br>Norma sandy loam<br>Norma silty clay<br>Norma-Cagey complex<br>Norma-Hale complex | CL-ML<br>ML-CL-SC | A-2, A-4<br>A-2, A-4 | Good to fair | Poor | Not suitable | Very poor | Susceptibility to frost action:high. Shearing strength: low to mod. Load carrying capacity: low. Subject to high water table and flooding. May become "quick" when wet. Shrink-swell potential: moderate.<br>Permeability: subsoil, 0.05-0.2; substrata, variable 0.05-2.5 |
| Nuby silt loam | ML<br>SM | A-7, A-2<br>A-2 | Good | Not suitable | Not suitable | Fair to good | Susceptibility to frost action: high. Shearing strength: low to mod. Load carrying capacity: low, especially when wet. Subject to periodic flooding and seasonal water table. Shrink-swell potential: low.<br>Permeability: subsoil, 0.2-0.8; substratum, 2.5-5.0 |
| Olete very grav. silt loam | GM-GC<br>GM-GC | A-1, A-2<br>A-1, A-2 | Very poor | Not suitable | Not suitable | Good | Susceptibility to frost action: slight. Shearing strength: mod. to high. Load carrying capacity: high. Basalt bedrock at depths of 1 to 3 feet. Shrink-swell potential: low.<br>Permeability: subsoil, 0.8-2.5; substratum, less than 0.05. |
| Olympic silty clay loam<br>Olympic stony clay loam | ML<br>CL | A-6<br>A-6 | Fair to good | Not suitable | Not suitable | Poor | Susceptibility to frost action: high. Shearing strength: low to mod. Load carrying capacity: moderate. Basalt bedrock at 2 to 5 feet. Shrink-swell potential: moderate.<br>Permeability: subsoil, 0.2-0.8; substrata, 0.2-0.8 |

Table 15. Soil features affecting engineering practices on highways. Puget Sound Area (con.)

| Soil Series and Type | Engineering Classification | | Suitability as Source of | | | | Highway Location and Trafficability |
|---|---|---|---|---|---|---|---|
| | Unified | AASHO | Topsoil | Sand | Gravel | Roadfill | |
| Orcas (Greenwood) peat | Pt | A-8 | Not suitable | Not suitable | Not suitable | Not suitable | Not suitable for highways. Shearing strength: very low. Load carrying capacity: very low. Shrink-swell potential: high. Permeability: subsoil, 0.8-2.5; substratum, 0.8-2.5 |
| Orcas peat, shallow over gravel | Pt<br>GC | A-8<br>A-6, A-7-6 | Not suitable | Not suitable | Fair to poor | Not suitable to good | Susceptibility to frost action: slight on gravel. Shearing strength: peat - very low; gravel - moderate. Load carrying capacity: low. Shrink-swell potential: peat - high; gravel - low. Permeability: subsoil, 0.05-0.2; substratum, less than 0.05 |
| Orting grav. sandy loam<br>Orting loam<br>Orting sandy loam<br>Orting stony sandy loam | SM<br>SM | A-1<br>A-1 | Fair | Not suitable | Not suitable | Good | Susceptibility to frost action: moderate. Shearing strength: moderate to high. Load carrying capacity: high. Dense, cemented gravelly, cobbly and stony gravelly glacial till at 1-1/2 to 2-1/2 feet. May become "quick" when saturated. Shrink-swell potential: low. Permeability: subsoil, 0.05-0.2; substrata, 0.05-0.2 |
| Oso silt loam<br>Oso loam | ML<br>SM-GM | A-4<br>A-4 | Good | Not suitable | Not suitable | Fair to good | Susceptibility to frost action: moderate to high. Shearing strength low to high. Load carrying capacity: high; may become "quick" when saturated. Cemented glacial till over argillite bedrock at 3 to 6 feet. May have seasonal water table and seep areas. Shrink-swell potential: low. Permeability: subsoil, 0.2-0.8; substrata, 0.05-0.2 |
| Pickett-Rock outcrop complex | ML-CL<br>SC | A-4, A-6<br>A-2 | Good | Not suitable | Not suitable | Fair | Susceptibility to frost action: moderate. Shearing strength: low to high. Load carrying capacity: moderate. Low when wet. Arkose sandstone at 1 to 3 feet. Shrink-swell potential: moderate. Permeability: subsoil 0.8-2.5; substratum, less than 0.05 |
| Pilchuck sand<br>Pilchuck fine sand<br>Pilchuck loamy fine sand | SM<br>SM | A-4<br>A-4 | Poor | Good | Poor | Good | Susceptibility to frost action: slight. Shearing strength: mod. to high. Load carrying capacity: high, except when dry. Subject to flooding. Shrink-swell potential: low Permeability: subsoil, 5.0-10.0; substrata, more than 10.0 |
| Pilchuck loamy sand<br>Pilchuck grav. sand<br>Pilchuck grav. loamy sand | SM<br>SM | A-4<br>A-4, A-2 | | | | | |
| Pilchuck fine sandy loam<br>Pilchuck sandy loam | SM-SP<br>SP | A-1, A-3 | Fair to poor | Good | Not suitable | Good | Susceptibility to frost action: slight. Shearing strength: high to mod. Load carrying capacity: high. Subject to periodic flooding. Shrink-swell potential: low. Permeability: subsoil, 5.0-10.0; substrata, over 10.0 |
| Pondilia fine sand | SM | A-2 | Fair | Fair | Not suitable | Good | Susceptibility to frost action: slight. Shearing strength: low to mod. Load carrying capacity: high. Shrink-swell potential: low. Permeability: subsoil, 5.0-10.0; substratum, 5.0-10.0 |

Table 15. Soil features affecting engineering practices on highways, Puget Sound Area (con.)

| Soil Series and Type | Engineering Classification | | Suitability as Source of | | | | Highway Location and Trafficability |
|---|---|---|---|---|---|---|---|
| | Unified | AASHO | Topsoil | Sand | Gravel | Roadfill | |
| Prather silty clay loam | CH<br>MH | A-7-6<br>A-7-6 | Fair | Not suitable | Not suitable | Very poor | Susceptibility to frost action: moderate to very high. Shearing strength: very low. Load carrying capacity: high. Very low when saturated. May have seasonal water table and seep areas. Shrink-swell potential: high. Permeability: subsoil, 0.05-0.2; substratum, less than 0.05 |
| Puget loam<br>Puget silt loam | ML-MH<br>ML-Mh | A-5<br>A-5 | Good | Not suitable | Not suitable | Very poor to not suitable | Susceptibility to frost action: high to very high. Shearing strength: very low. Load carrying capacity: low, except when quite dry. May become "quick" when saturated. May be subject to periodic flooding and high water table. Shrink-swell potential: mod. Permeability: subsoil, 0.2-0.8; substrata, 0.05-0.2 |
| Puget silty clay loam<br>Puget clay loam | OL-ML<br>ML-MH | A-5, A-7<br>A-4, A-7 | | | | | |
| Puget fine sandy loam<br>Puget very fine sandy loam | SM<br>SM-ML | A-2<br>A-4 | Fair | Not suitable | Not suitable | Fair to good | Susceptibility to frost action: moderate. Shearing strength: low to high. Load carrying capacity: high. May be low when saturated or very dry. Shrink-swell potential: low Permeability: subsoil, 0.2-0.8; substrata, 0.05-0.2 |
| Puget clay<br>Puget silty clay | MH<br>MH | A-7<br>A-7 | Good | Not suitable | Not suitable | Not suitable | Susceptibility to frost action: very high. Shearing strength: very low. Load carrying capacity: low. May be subject to periodic flooding. Shrink-swell potential: high Permeability: subsoil, 0.2-0.8; substrata, 0.05-0.2 |
| *Puyallup fine sandy loam*<br>Puyallup sandy loam | SM<br>SM | A-4<br>A-2, A-4 | Fair | Fair | Not suitable | Good | Susceptibility to frost action: slight. Shearing strength: moderate to high. Load carrying capacity: high, except when dry or *saturated*. May be subject to periodic flooding. Shrink-swell potential: low. Permeability: subsoil, 0.8-2.5; substrata, 5.0-10.0 |
| Puyallup very fine sandy loam | SM<br>ML | A-1, A-2<br>A-4 | Good | Fair | Not suitable | Good | |
| Puyallup silt loam<br>Puyallup loam | ML-MH<br>ML-MH | A-5<br>A-5 | Good | Not suitable | Not suitable | Good | Susceptibility to frost action: high. Shearing strength: very low. Load carrying capacity: low. May become "quick" when saturated. May be subject to periodic flooding. Shrink-swell potential: low Permeability: subsoil, 0.8-2.5; substrata, 5.0-10.0 |
| Puyallup silty clay loam | ML-SM<br>SM-ML | A-4, A-2<br>A-2, A-4 | Good | Not suitable | Not suitable | Fair | Susceptibility to frost action: moderate. Shearing strength: low to moderate. Load carrying capacity: low. May be subject to periodic flooding. Shrink-swell potential: low. Permeability: subsoil, 0.8-2.5; substrata, 5.0-10.0 |
| Puyallup loamy sand over Puget | SM<br>SM-ML | A-4<br>A-2, A-4 | | | | | |
| Quilcene silty clay loam | CL<br>GC | A-6<br>A-1 | Fair to good | Not suitable | Not suitable | Very poor | Susceptibility to frost action: moderate to high. Shearing strength: moderate to high. Load carrying capacity: moderate. Shrink-swell potential: moderate. Permeability: subsoil, 0.2-0.8; substratum, 0.05-0.2 |

Table 15. Soil features affecting engineering practices on highways, Puget Sound Area (con.)

| Soil Series and Type | Engineering Classification | | Suitability as Source of | | | | Highway Location and Trafficability |
|---|---|---|---|---|---|---|---|
| | Unified | AASHO | Topsoil | Sand | Gravel | Roadfill | |
| Ragnar fine sandy loam | ML-SM<br>SP-SM | A-4<br>A-6 | Fair | Poor to good | Not suitable | Good | Susceptibility to frost action: moderate. Shearing strength: subsoils - low; substrata - high. Load carrying capacity: high, except when very dry. Shrink-swell potential: low<br>Permeability: subsoil, 5.0-10.0; substratum, 5.0-10.0 |
| Reed clay | CH<br>CH | A-7<br>A-7 | Poor | Not suitable | Not suitable | Not suitable | Susceptibility to frost action: moderate. Shearing strength: very low. Load carrying capacity: high, except when saturated. Subject to seasonal flooding. Shrink-swell potential: high<br>Permeability: subsoil, less than 0.05; substrata, less than 0.05 |
| Reed silty clay loam | CH<br>CL-CH | A-7<br>A-7, A-2 | | | | | |
| Riverwash | GP | A-1 | Not suitable | Very poor | Excellent | Good | Susceptibility to frost action: none. Shearing strength: high. Load carrying capacity: high. Subject to periodic flooding. Shrink-swell potential: low.<br>Permeability: subsoil, 5.0-10.0; substratum, 5.0-10.0 |
| Roche gravelly loam | GM<br>SC | A-2<br>A-4, A-6 | Fair | Not suitable | Not suitable | Fair to good | Susceptibility to frost action: moderate. Shearing strength: moderate to high. Load carrying capacity: high, except when saturated. Subject to seasonal water table and seep areas. Cemented silty glacial till at 2-1/2 to 4 feet. Shrink-swell potential: low to moderate.<br>Permeability: subsoil, 0.05-0.2; substrata, less than 0.05 |
| Roche-Rockland complex<br>Roche stony loam<br>Roche-Rock outcrop complex | SM<br>SC | A-1, A-2<br>A-1, A-2 | | | | | |
| Roche stony sandy loam<br>Roche gravelly sandy loam | SM<br>SM | A-1, A-2<br>A-1, A-2 | | | | | |
| Roche loam | SM<br>SM | A-4<br>A-4 | Fair | Not suitable | Not suitable | Good to fair | Susceptibility to frost action: moderate. Shearing strength: moderate to high. Load carrying capacity: high. May become "quick" when saturated. Cemented silty glacial till at 2-1/2 to 4 feet. Subject to seasonal water table. Shrink-swell potential: low.<br>Permeability: subsoil, 0.05-0.2; substratum, less than 0.05 |
| Rock land<br>Rough Mountainous land | SM<br>bedrock | A-2 | Not suitable | Not suitable | Not suitable | Good | Susceptibility to frost action: high. Shearing strength: mod. to high. Load carrying capacity: low to high. Shrink-swell potential: high<br>Permeability: subsoil 0.2-0.8; substrata, less than 0.05<br>Argillite, basalt, granite, schist, shale or sandstone at less than 1 foot to 6 feet or more. |
| Rough broken land<br>Rough stony land | See interpretations for adjoining soil areas. | | | | | | |
| Rough broken land<br>Olympic soil material | ML<br>CL | A-6<br>A-6 | Fair | Not suitable | Not suitable | Poor | Susceptibility to frost action: high. Shearing strength: very low to mod. Load carrying capacity: moderate. May become "quick" when saturated. Basalt bedrock at less than 2 to more than 5 feet. Shrink-swell potential: moderate.<br>Permeability: subsoil. 0.2-0.8; substrata, 0.2-0.8 |

Table 15. Soil features affecting engineering practices on highways, Puget Sound Area (con.)

| Soil Series and Type | Engineering Classification | | Suitability as Source of | | | | Highway Location and Trafficability |
|---|---|---|---|---|---|---|---|
| | Unified | AASHO | Topsoil | Sand | Gravel | Roadfill | |
| Salal fine sandy loam<br>Salal silt loam | SM<br>ML | A-2<br>A-5, A-4 | Fair to good | Poor | Not suitable | Fair (Mica-ceous) | Susceptibility to frost action: high. Shearing strength: very low to mod. Load carrying capacity: low to moderate. Subject to periodic flooding. Shrink-swell potential: low to moderate<br>Permeability: subsoil, 0.2-0.8; substrata, 0.8-2.5 |
| Samish silt loam<br>Samish silty clay loam | ML<br>MH | A-4, A-7<br>A-7 | Good | Not suitable | Not suitable | Very poor (Mica schist & talc) | Susceptibility to frost action: very high. Shearing strength: very low to mod. Load carrying capacity: high, except when saturated. Subject to periodic overflow. Cracks when dry. Shrink-swell potential: high.<br>Permeability: subsoil, 0.2-0.8; substrata, 0.05-0.2 |
| Sammamish silt loam | ML<br>MH | A-4<br>A-4, A-7 | Good | Not suitable | Not suitable | Very poor | Susceptibility to frost action: very high. Shearing strength: very low to mod. Load carrying capacity: low. May become "quick" when saturated. Subject to periodic flooding and high water table.<br>Shrink-swell potential: high.<br>Permeability: subsoil, 0.05-0.2; substratum, 0.05-0.2 |
| San Juan coarse sandy loam | GP-GM<br>GW-GM | A-1<br>A-1 | Poor | Very poor | Excellent to good | Good | Susceptibility to frost action: none. Shearing strength: very high to moderate. Load carrying capacity: high, except when dry.<br>Shrink-swell potential: low.<br>Permeability: subsoil, 5.0-10.0; substrata, 5.0-10.0 |
| San Juan grav. sandy loam<br>San Juan stony sandy loam | SW<br>SW | A-1<br>A-1 | | | | | |
| San Juan grav. sandy loam, moderately deep | SP-SM<br>CL-SC | A-1, A-2<br>A-6, A-2 | Fair | Not suitable | Not suitable | Good | Susceptibility to frost action: slight. Shearing strength: high to mod. Load carrying capacity: high, except when saturated. Cemented gravelly sandy clay glacial till. Subject to seasonal water table and seep areas. Shrink-swell potential: low<br>Permeability: subsoil, 0.8-2.5; substrata, 0.05-0.2 |
| San Juan loam, moderately deep<br>San Juan stony loam, moderately deep | GM-SP<br>GC-SC | A-2<br>A-2, A-6 | | | | | |
| Sauk loam | ML<br>SM | A-4, A-7<br>A-7 | Fair | Poor | Very poor | Good | Susceptibility to frost action: slight. Shearing strength: low to moderate. Load carrying capacity: high. Shrink-swell potential: low.<br>Permeability: subsoil, 0.8-2.5; substratum, 2.5-5.0 |
| Saxon silt loam | ML<br>CL | A-5<br>A-6 | Fair | Not suitable | Not suitable | Poor | Susceptibility to frost action: high. Shearing strength: low to mod. Load carrying capacity: moderate. Cemented gravelly silty clay glacial till at 3 to 4 feet. May have seasonal water table.<br>Shrink-swell potential: moderate.<br>Permeability: subsoil, 0.2-0.8; substratum, 0.05-0.2 |
| Schnorbush loam<br>Schnorbush loam - Norma silty clay loam | GC<br>GC | A-2<br>A-2 | Very poor | Not suitable | Not suitable | Good | Susceptibility to frost action: slight. Shearing strength: mod. to high. Load carrying capacity: high. Shrink-swell potential: low.<br>Permeability: subsoil, 0.2-0.8; substrata, 0.2-0.8 |

Table 15. Soil features affecting engineering practices on highways, Puget Sound Area (con.)

| Soil Series and Type | Engineering Classification | | Suitability as Source of | | | | Highway Location and Trafficability |
|---|---|---|---|---|---|---|---|
| | Unified | AASHO | Topsoil | Sand | Gravel | Roadfill | |
| Schooley loam | SM<br>CH-OH | A-4<br>A-7-6 | Fair | Poor | Not suitable | Good | Susceptibility to frost action: moderate. Shearing strength: low. Load carrying capacity: high, except when saturated. Subject to high water table. Shrink-swell potential: low<br>Permeability: subsoil, 2.5-5.0; substratum, less than 0.05 |
| Sequim clay loam | GM-GC<br>GM-GP | A-4, A-6<br>A-2 | Poor | Very poor | Poor | Good | Susceptibility to frost action: moderate. Shearing strength: mod. to high. Load carrying capacity: high. Subject to water table. Shrink-swell potential: low<br>Permeability: subsoil, 0.8-2.5; substrata, 0.2-0.8 |
| Sequim gravelly loam | GM<br>GM-GP | A-4<br>A-2 | | | | | |
| Shelton gravelly loam<br>Shelton gravelly sandy loam | GM<br>SM-GM | A-2<br>A-2 | Poor | Poor | Poor | Good | Susceptibility to frost action: slight. Shearing strength: high to mod. Load carrying capacity: high. Cemented gravelly sandy glacial till at 2-1/2 to 4 feet. May be subject to seasonal water table. Shrink-swell potential: low.<br>Permeability: subsoil, 0.8-2.5; substrata, 0.05-0.2 |
| Shuwah silty clay loam | OH<br>CH | A-7-5<br>A-7-6 | Fair | Not suitable | Not suitable | Not suitable | Susceptibility to frost action: moderate. Shearing strength: very low. Load carrying capacity: moderate to high, except when saturated. Subject to periodic flooding. May have seasonal water table. Shrink-swell potential: high.<br>Permeability: subsoil, 0.2-0.8; substratum, 0.2-0.8 |
| Sinclair clay loam<br>Sinclair shotty loam<br>Sinclair grav. loam<br>Sinclair grav.fine sandy loam<br>Sinclair grav. sandy loam | SM<br>SM | A-2<br>A-2 | Fair | Not suitable | Very poor | Good | Susceptibility to frost action: moderate. Shearing strength: moderate to high. Load carrying capacity: high. Firly cemented gravelly sandy loam glacial till at 2-1/2 to 3 feet. May be subject to seasonal water table. Shrink-swell potential: low.<br>Permeability: subsoil, 0.2-0.8; substrata, 0.05-0.2 |
| Skagit silty clay loam | ML<br>ML | A-6<br>A-4 | Good | Not suitable | Not suitable | Fair | Susceptibility to frost action: high. Shearing strength: low to mod. Load carrying capacity: low. May become "quick" when saturated. May be subject to high water table. Shrink-swell potential: moderate.<br>Permeability: subsoil, less than 0.05; substratum, less than 0.05 |
| Skiyou gravelly loam | ML<br>GM | A-4<br>A-2 | Very poor | Not suitable | Poor | Fair (Micaceous schist) | Susceptibility to frost action: none. Shearing strength: moderate. Load carrying capacity: high, except when saturated. Strongly cemented gravelly .andy loam glacial till from schist and argillite. May have seasonal water table. May become "quick" when saturated. Topography - rolling to steep. Shrink-swell potential: low<br>Permeability: subsoil, 0.2-0.8; substratum, 0.05-0.2 |

Table 15. Soil features affecting engineering practices on highways, Puget Sound Area (con.)

| Soil Series and Type | Engineering Classification | | Suitability as Source of | | | | Highway Location and Trafficability |
|---|---|---|---|---|---|---|---|
| | Unified | AASHO | Topsoil | Sand | Gravel | Roadfill | |
| Skokomish silt loam | ML<br>SM-CL | A-4, A-6<br>A-4, A-6 | Good | Not suitable | Not suitable | Fair to poor | Susceptibility to frost action: moderate to high. Shearing strength: moderate.. Load carrying capacity: moderate. Very low when saturated. Subject to periodic flooding and high water table. May become "quick" when wet. Shrink-swell potential: moderate. Permeability: subsoil, 0.2-0.8; substratum, 0.05-0.2 |
| Skykomish cobbly sandy loam<br>Skykomish grav. sandy loam<br>Skykomish grav. loam<br>Skykomish stony loam | GW-GP<br>GW-GP | A-1<br>A-1 | Not suitable | Not suitable | Excellent | Good | Susceptibility to frost action: none. Shearing strength: very high. Load carrying capacity: high. Topography nearly level to hilly. Shrink-swell potential: low. Permeability: subsoil, 5.0-10.0: substrata, more than 10.0 |
| Skykomish stony sand | SW-GW<br>SW-GW | A-3<br>A-3 | Not suitable | Fair to not suitable | Very good to fair | Good | Susceptibility to frost action: none. Shearing strength: very high. Load carrying capacity: high. Shrink-swell potential: low Permeability: subsoil, 5.0-10.0; substrata, 5.0-10.0 |
| Skykomish gravelly sand | SW<br>SW | A-3<br>A-3 | | | | | |
| Smith Creek gravelly loam | SM<br>SP | A-4<br>A-1 | Fair to not suitable | Fair to good | Poor | Good | Susceptibility to frost action: slight. Shearing strength: high to mod. Load carrying capacity: high. Shrink-swell potential: low. Permeability: subsoil, 0.8-2.5; substratum, 2.5-10.0 |
| Snakelum coarse sandy loam | SM<br>SP | A-2<br>A-1 | Fair to very poor | Good to excellent | Very poor | Good | Susceptibility to frost action: slight. Shearing strength: mod. to high. Load carrying capacity: high, except when dry. Shrink-swell potential: low. Permeability: subsoil, 5.0-10.0; substratum, 5.0-10.0 |
| Snohomish fine sandy loam<br>Snohomish loamy fine sand | SM<br>Pt | A-7<br>A-8 | Fair to good | Not suitable | Not suitable | Surface and sub-soil fair to good. Substrata not suitable | Susceptibility to frost action: high. Shearing strength: very low. Load carrying capacity: low. Peat substrata unsuited as foundations. Shrinks and settles. Subject to periodic flooding and high water table. Shrink-swell potential: high Permeability: subsoil, 0.2- 0.8; substrata, 0.2-0.8 |
| Snohomish loam<br>Snohomish silt loam | ML-SM<br>Pt | A-5, A-4<br>A-8 | | | | | |
| Snohomish silty clay<br>Snohomish silty clay loam | CH<br>Pt | A-7<br>A-8 | Fair | Not suitable | Not suitable | Not suitable | Susceptibility to frost action: high. Shearing strength: very low. Load carrying capacity: low. May be subject to flooding. Peat substrata unsuited as foundations. Shrink-swell potential: high Permeability: subsoil, 0.2-0.8; substrata. 0.2-0.8 |
| Snoqualmie gravelly loam | SM<br>SM | A-2, A-4<br>A-2, A-4 | Fair | Poor | Good | Good | Susceptibility to frost action: moderate. Shearing strength: mod. to high. Load carrying capacity: high. Shrink-swell potential: low Permeability: subsoil, 2.5-5.0; substratum, 5.0-10.0 |

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| Soil Series and Type | Engineering Classification | | Suitability as Source of | | | | Highway Location and Trafficability |
|---|---|---|---|---|---|---|---|
| | Unified | AASHO | Topsoil | Sand | Gravel | Roadfill | |
| Snoqualmie grav. sandy loam<br>Snoqualmie grav. loamy sand | SM<br>GW | A-2<br>A-1 | Poor to not suitable | Poor | Excellent | Good | Susceptibility to frost action: none. Shearing strength: moderate to very high. Load carrying capacity: high, except when very dry. Shrink-swell potential: low.<br>Permeability: subsoil, 2.5-5.0; substrata, 5.0-10.0 |
| Sol Duc grav. loam<br>Sol Duc grav. sandy loam | SM<br>GP-GM | A-4, A-6<br>A-2, A-4 | Fair to not suitable | Poor | Good to excellent | Good | Susceptibility to frost action: slight. Shearing strength: mod. to high. Load carrying capacity: high. Shrink-swell potential: low.<br>Permeability: subsoil, 2.5-5.0; substrata, 5.0-10.0 |
| Spalding peat | Pt<br>Pt | A-8<br>A-8 | Not suitable | Not suitable | Not suitable | Not suitable | Low volume weight; low strength. High water table and periodic flooding. May be salty. |
| Spalding peat, burned phase | GM-GP<br>GM-GP | A-2<br>A-2 | Not suitable | Not suitable | Fair - May be salty | Good | Susceptibility to frost action: low. Shearing strength: high. Load carrying capacity: high; may be subject to flooding and high water table. Shrink-swell potential: low.<br>Permeability: subsoil, 0.2-0.8; substratum, 0.2-0.8 |
| Spanaway grav. sandy loam<br>Spanaway stony sandy loam<br>Spanaway stony loam | GW-GM<br>GW | A-1<br>A-1 | Poor | Not suitable | Excellent to good | Good | Susceptibility to frost action: slight. Shearing strength: very high to moderate. Load carrying capacity: high. Shrink-swell potential: low<br>Permeability: subsoil, 5.0-10.0; substrata, 5.0-10.0 |
| Squalicum silt loam | ML<br>CL | A-4<br>A-6, A-4 | Good | Not suitable | Not suitable | Poor | Susceptibility to frost action: high. Shearing strength: low to mod. Load carrying capacity: moderate to low. May become "quick" when saturated. Compact, cemented gravelly, cobbly and stony sandy clay glacial till. May be subject to seasonal water table and seep areas. Topography rolling to steep. Shrink-swell potential: moderate.<br>Permeability: subsoil, 0.2-0.8; substrata, less than 0.05 |
| Squalicum/Alderwood silt loams<br>Squalicum grav. silt loam<br>Squalicum stony silt loam<br>Squalicum/Alderwood stony silt loams | SM<br>SM | A-4<br>A-4 | | | | | |
| Steep broken land | See adjacent Alderwood, Everett, Kitsap or Indianola soils. | | | | | | |
| Stossel clay loam<br>Stossel stony loam | GM<br>CL | A-2<br>A-7 | Very poor | Not suitable | Not suitable | Very poor | Susceptibility to frost action: moderate. Shearing strength: low to high. Load carrying capacity: moderate, except when wet. Cracks when dry. Shale at 3 to 6 feet. May be subject to seasonal water table and seep areas. Topography rolling to steep. Shrink-swell potential: high.<br>Permeability: subsoil, 0.05-0.2; substrata, less than 0.05 |

Table 15. Soil features affecting engineering practices on highways, Puget Sound Area (con.)

| Soil Series and Type | Engineering Classification | | Suitability as Source of | | | | Highway Location and Trafficability |
|---|---|---|---|---|---|---|---|
| | Unified | AASHO | Topsoil | Sand | Gravel | Roadfill | |
| Sultan silt loam<br>Sultan loam | ML<br>SM-CL | A-5<br>A-2, A-4 | Good | Not suitable | Not suitable | Very poor to good | Susceptibility to frost action: moderate. Shearing strength: low to moderate. Load carrying capacity: high, except when wet. May become "quick@ when saturated. May be subject to periodic flooding and seasonal water table. Shrink-swell potential: low to moderate. Permeability: subsoil, 0.2-0.8; substrata, 0.8-2.5 |
| Sultan clay loam | CL<br>CL | A-4, A-6<br>A-4, A-6 | | | | | |
| Sultan fine sandy loam<br>Sultan sandy loam | SM<br>ML | A-2<br>A-4 | Good to fair | Not suitable | Not suitable | Fair to good | Susceptibility to frost action: moderate. Shearing strength: low to moderate. Load carrying capacity: moderate to low. Very low when saturated. May be subject to periodic flooding and seasonal water table. Shrink-swell potential: low. Permeability: subsoil, 0.2-0.8; substrata, 0.8-2.5 |
| Sultan silt loam, shallow over Buckley | ML<br>SM | A-2<br>A-2, A-5 | Good to fair | Not suitable | Not suitable | Fair | Susceptibility to frost action: moderate. Shearing strength: low to moderate. Load carrying capacity: high. Low when wet. Dense, cemented sandy loam glacial till at 2 to 3 feet. May be subject to seasonal water table. Shrink-swell potential: low. Permeability: subsoil, 0.2-0.8; substratum, less than 0.05 |
| Sumas silt loam<br>Sumas fine sandy loam | MH<br>SW | A-7<br>A-1 | Good to poor | Good | Not suitable | Sub-strata, good. Subsoil, poor. | Susceptibility to frost action: high. Shearing strength: low to high. Load carrying capacity: high. Very low when saturated. May be subject to periodic flooding and seasonal water table. Shrink-swell potential: moderate. Permeability: subsoil, 0.2-0.8; substrata, 0.2-0.8 |
| Sumas silty clay loam | MH<br>ML-SM | A-7<br>A-4, A-2 | Good to fair | Not suitable | Not suitable | Fair to not suitable | Susceptibility to frost action: high. Shearing strength: very low to moderate. Load carrying capacity: high. May be subject to periodic flooding and seasonal water table. May become "quick" when saturated. Shrink-swell potential: moderate. Permeability: subsoil, 0.2-0.8, substratum, 0.2-0.8 |
| Swantown grav. loam<br>Swantown loam | CL<br>SM-SC | A-4<br>A-4 | Fair | Not suitable | Not suitable | Fair to poor | Susceptibility to frost action: moderate to high. Shearing strength: low to high. Load carrying capacity: moderate to high. Dense, cemented gravelly loam glacial till. May have seasonal water table and seep areas. Shrink-swell potential: low to moderate. Permeability: subsoil, 0.2-0.8; substrata, less than 0.05 |
| Swantown grav. sandy loam | SM<br>SM-GW | A-2<br>A-2, A-1 | Fair | Not suitable | Poor (cemented) | Good | Susceptibility to frost action: slight. Shearing strength: moderate to high. Load carrying capacity: high, except when saturated. Dense cemented gravelly loam glacial till. May have seasonal water table and seep areas. Shrink-swell potential: low to moderate. Permeability: subsoil, 0.2-0.8; substratum less than 0.05 |
| Tacoma muck<br>Tacoma peat | Pt<br>Pt | A-8<br>A-8 | Not suitable | Not suitable | Not suitable | Not suitable | Not suitable for highway location; Shearing strength: very low. Load carrying capacity: very low. Shrink-swell potential: high Permeability: subsoil, 0.2-0.8; substrata, 0.2-0.8 |

Table 15. Soil features affecting engineering practices on highways, Puget Sound Area (con.)

| Soil Series and Type | Engineering Classification: Unified | Engineering Classification: AASHO | Suitability as Source of: Topsoil | Sand | Gravel | Roadfill | Highway Location and Trafficability |
|---|---|---|---|---|---|---|---|
| Tanwax peat<br>Tanwax peat, shallow over peat | Pt<br>Pt | A-8<br>A-8 | Fair | Not suitable | Not suitable | Not suitable | Not suitable for highway location. Shearing strength: very low. Load carrying capacity: very low. Subject to high water table, settling and flooding. Shrink-swell potential: high<br>Permeability: subsoil, 0.05-0.2; substrata, less than 0.05 |
| Tanwax peat, shallow over glacial till | Pt<br>SM-GM | A-8<br>A-1, A-2 | Fair | Not suitable | Not suitable | Peat not suitable. Glacial till good. | Susceptibility to frost action: high to slight. Shearing strength: very low to high. Load carrying capacity: very low to high. Cemented glacial till at 2 to 3 feet. Subject to high water table. Shrink-swell potential: high.<br>Permeability: subsoil, 0.05-0.2; substratum, less than 0.05 |
| Tebo gravelly loam<br>Tebo loam | ML<br>CL | A-6<br>A-6 | Fair to good | Not suitable | Not suitable | Poor | Susceptibility to frost action: high. Shearing strength: low to mod. Load carrying capacity: moderate. May become "quick" when saturated. Basalt bedrock at 3 to 6 feet. May be subject to seep areas. Shrink-swell potential: moderate.<br>Permeability: subsoil, 0.2-0.8; substrata, 0.05-0.2 |
| Tenino gravelly sandy loam | GW<br>GW-GM | A-4<br>A-1, A-2 | Not suitable | Very poor | Fair to very good | Good | Susceptibility to frost action: slight. Shearing strength: very high to moderate. Load carrying capacity: high. Weakly cemented gravelly sandy glacial till. May be subject to seep areas. Shrink-swell potential: low.<br>Permeability: subsoil, 0.8-2.5; substratum, 0.2-0.8 |
| Thornton clay<br>Thornton silty clay loam | ML<br>ML | A-6, A-7<br>A-6, A-7 | Fair to very poor | Very poor | Not suitable | Poor to fair | Susceptibility to frost action: very high. Shearing strength: low to mod. Load carrying capacity: low. Subject to high water table and periodic flooding. Shrink-swell potential: high.<br>Permeability: subsoil, less than 0.05; substrata, less than 0.05 |
| Thornwood grav. loam<br>Thornwood grav. sandy loam | GW<br>GW-GM | A-2<br>A-1 | Poor to not suitable | Very poor | Fair (schist) | Fair (schist) | Susceptibility to frost action: none. Shearing strength: very high. Load carrying capacity: high. Schist gravel, and sand subject to disintegrating. Shrink-swell potential: low.<br>Permeability: subsoil, 2.5-5.0; substrata, 5.0-10.0 |
| Tidal marsh | Pt<br>ML-CL | A-8<br>A-6, A-7 | Very poor (salty) | Not suitable | Not suitable | Not suitable | Susceptibility to frost action: high. Shearing strength: very low. Load carrying capacity: very low. Periodic flooding. Very unstable. Shrink-swell potential: high.<br>Permeability: subsoil, 0.05-0.2; substratum, 0.05-0.2 |
| Tisch silt loam | MH<br>SM-ML | A-5<br>A-4, A-7 | Fair to poor | Not suitable | Not suitable | Good | Susceptibility to frost action: high. Shearing strength: low to moderate. Load carrying capacity: very low to moderate. Subject to flooding and water table. Shrink-swell potential: low.<br>Permeability: subsoil, 0.05-0.2; substrata, 0.05-0.2 |
| Tisch silty clay loam | MH-OH<br>SM | A-5, A-7<br>A-4 | | | | | |

Table 15. Soil features affecting engineering practices on highways, Puget Sound Area (con.)

| Soil Series and Type | Engineering Classification | | Suitability as Source of | | | | Highway Location and Trafficability |
|---|---|---|---|---|---|---|---|
| | Unified | AASHO | Topsoil | Sand | Gravel | Roadfill | |
| Tokul gravelly sandy loam | SM<br>SM | A-4<br>A-4, A-2 | Fair | Not suitable | Not suitable | Good | Susceptibility to frost action: moderate. Shearing strength: moderate to high, depending upon moisture. Load carrying capacity: high, except when saturated. Moderately cemented gravelly sandy loam glacial till at 3 to 4 feet. May be subject to seasonal water table. Shrink-swell potential: low.<br>Permeability: subsoil, 0.8-2.5; substratum, 0.05-0.2 |
| Townsend gravelly loam<br>Townsend fine sandy loam<br>Townsend sandy loam | SM<br>GW-GM | A-1<br>A-1 | Fair to poor | Poor | Poor | Good | Susceptibility to frost action: moderate. Shearing strength: low to very high. Load carrying capacity: high. Cemented gravelly sandy loam glacial till at 3 to 4 feet. May be subject to seep areas. Shrink-swell potential: low.<br>Permeability: subsoil, 0.8-2.5; substratum, 0.05-0.2 |
| Triton very gravelly loam | GM<br>GM | A-1<br>A-1 | Very poor | Poor | Poor | Good | Susceptibility to frost action: slight. Shearing strength: mod. to high. Load carrying capacity: high. Basalt bedrock at shallow depths. Shrink-swell potential: low.<br>Permeability: subsoil, 0.8-2.5; substratum, less than 0.05 |
| Tromp silt loam<br>Tromp silty clay loam<br>Tromp-Edmonds silt loams | SM<br>SM | A-2<br>A-2 | Fair | Poor to good | Not suitable | Good | Susceptibility to frost action: moderate. Shearing strength: moderate to high. Load carrying capacity: high, except when saturated. Sporadic iron hardpan. Subject to water table. May become "quick" when saturated. Shrink-swell potential: low.<br>Permeability: subsoil, 0.05-0.2; substrata, 0.8-2.5 |
| Tromp-Custer silt loams<br>Tromp-Woodlyn silt loams | ML-SM<br>SM | A-4, A-2<br>A-4, A-2 | Fair | Poor to good | Not suitable | Fair | |
| Tromp-Tisch silt loams complex | SM-MH<br>SM | A-2, A-5<br>A-2 | Fair | Fair | Not suitable | Fair to very poor | Susceptibility to frost action: slight to high. Shearing strength: low to moderate. Load carrying capacity: high to low. Sporadic iron hardpan. Subject to water table. May become "quick" when saturated. Shrink-swell potential: low to high.<br>Permeability: subsoil, 0.05-0.2; substrata, 0.8-2.5 |
| Tumwater loamy fine sand<br>Tumwater fine sandy loam | SM<br>SP-SM | A-2<br>A-3 | Fair to very poor | Good to excellent | Not suitable | Good | Susceptibility to frost action: slight. Shearing strength: moderate to high. Load carring capacity: high, except when very dry. Shrink-swell potential: low.<br>Permeability: subsoil, 5.0-10.0; substrata, 5.0-10.0 |
| Waddell loam<br>Waddell gravelly loam<br>Waddell silty clay loam | CL<br>CL | A-6<br>A-7-6 | Fair | Not suitable | Not suitable | Very poor | Susceptibility to frost action: high. Shearing strength: low to mod. Load carrying capacity: moderate, except when saturated. Shrink-swell potential: moderate.<br>Permeability: subsoil, 0.8-2.5: substrata, 0.2-0.8 |
| Wapato silty clay loam<br>Wapato clay loam<br>Wapato/Galvin silty clay complex | OH<br>CH | A-7<br>A-7 | Fair | Not suitable | Not suitable | Not suitable | Susceptibility to frost action: moderate. Shearing strength: very low. Load carrying capacity: moderate. Low to very low when saturated. Subject to flooding. Shrink-swell potential: high.<br>Permeability: subsoil, 0.05-0.2; substrata, less than 0.05. |
| Wapato silt loam | OH<br>CL-CH | A-7-5<br>A-7-6 | | | | | |

Table 15. Soil features affecting engineering practices on highways, Puget Sound Area (con.)

| Soil Series and Type | Engineering Classification | | Suitability as Source of | | | | Highway Location and Trafficability |
|---|---|---|---|---|---|---|---|
| | Unified | AASHO | Topsoil | Sand | Gravel | Roadfill | |
| Whatcom silt loam<br>Whatcom silt loam-McKenna silty clay loam complex | CL-MH<br>CL-MH | A-4, A-7<br>A-6, A-7 | Fair to good | Not suitable | Not suitable | Very poor to not suitable | Susceptibility to frost action: high to very high. Shearing strength: very low. Load carrying capacity: Low. May become "quick" when saturated. Subject to seasonal water table. Shrink-swell potential: high.<br>Permeability: subsoil, 0.2-0.8; substrata, less than 0.05 |
| Whidbey gravelly sandy loam | SM<br>GW-SM | A-2<br>A-2 | Fair to very poor | Not suitable | Poor | Good | Susceptibility to frost action: slight. Shearing strength: very high to low. Load carrying capacity: high, except when saturated. May become "quick". Strongly cemented gravelly loamy sand glacial till at 2 to 3 feet. May be subject to seasonal water table and seep areas. Shrink-swell potential: low.<br>Permeability: subsoil, 5.0-10.0; substratum, 0.05-0.2 |
| Wickersham shaly loam<br>Wickersham shaly silt loam | SM<br>GP | A-2<br>A-1 | Fair | Not suitable | Fair to very poor (schist gravel) | Fair to poor (schist-gravelly & flaggy) | Susceptibility to frost action: slight. Shearing strength: moderate to high. Load carrying capacity: moderate. Shrink-swell potential: low.<br>Permeability: subsoil, 2.5-5.0; substrata, 2.5-5.0 |
| Wilkeson loam<br>Wilkeson silt loam | SM<br>ML | A-5<br>A-5 | Fair | Not suitable | Not suitable | Fair | Susceptibility to frost action: high. Shearing strength: low to moderate. Load carrying capacity: high. Low when saturated. May become "quick". Dense clay or silty clay at 2-1/2 to 4 feet. May be subject to seasonal water table and seep areas.<br>Shrink-swell potential: low.<br>Permeability: subsoil, 0.2-0.8; substrata, less than 0.05 |
| Woodinville silt loam | OH<br>OH | A-5<br>A-5, A-7 | Fair | Not suitable | Not suitable | Not suitable | Susceptibility to frost action: moderate. Shearing strength: very low. Load carrying capacity: moderate, except when wet. May become "quick". Organic, diatomite, silty clay and clay. Subject to high water table. Shrink-swell potential: high.<br>Permeability: subsoil, less than 0.05; substratum, less than 0.05 |
| Woodlyn silt loam | ML<br>SM | A-4<br>A-4 | Fair | Fair | Not suitable | Fair to good | Susceptibility to frost action: slight. Shearing strength: very low to low. Load carrying capacity: high. Low when wet. Subject to water table. Shrink-swell potential: low.<br>Permeability: subsoil, 0.05-0.2; substratum, 0.8-2.5 |
| Winston grav. sandy loam | SM<br>SM | A-1<br>A-1 | Poor | Not suitable | Excellent | Good | Susceptibility to frost action: none. Load carrying capacity: high. Shrink-swell potential: low.<br>Permeability: subsoil, 2.5-5.0; substratum, 5.0-10.0 |

Table 16. Soil features affecting engineering practices for water impoundments or disposal, Puget Sound Area.

| Soil Series and Type | Dikes or Levees | Farm Ponds | | Terraces, Diversions and Waterways |
|---|---|---|---|---|
| | | Reservoir Area | Embankments | |
| Active dune land | Stability: moderate. Compacted permeability: pervious. Shrink-swell potential: low. Piping hazard through: fill - very high. Not suitable. | Permeability: subsoil, 5.0-10.0 in/hr; substrata, 5.0-10.0 in/hr. Not suitable. | Shearing strength: subsoil, high; substrata, high. Compacted permeability: pervious. Compressibility: very slight. Stability: subsoil, not suitable; substrata, not suitable. Piping: very high. | Resistance to erosion, low. Establishment of vegetation, difficult. |
| Agnew-Elwha* complex (*see Elwha silt loam) Agnew silty clay loam | Stability: moderate. Compacted permeability: semipervious to impervious. Shrink-swell potential: moderate to low. Piping hazard through: fill - high hazard. Not suitable. | Permeability: subsoil, 0.05-0.2 in/hr; substrata, less than 0.05 in/hr. Suitability: good to poor. | Shearing strength: subsoil, very low; substrata, moderate. Compacted permeability: semipervious to impervious. Compressibility: very slight to medium. Stability: subsoil, moderate; substrata, high. | Resistance to erosion, moderate. On cultivated slopes of 8-15%. Establishment of vegetation, fairly easy. |
| Agnew loam Agnew fine sandy loam Agnew sandy loam | Stability: moderate to low. Compacted permeability: semipervious to impervious. Shrink-swell potential: moderate to low. May crack when dry. Piping hazard through: fill - low. Good to poor. Use sheepsfoot roller or rubber-tired roller. | Permeability: subsoil, 0.05-0.2 in/hr; substrata, 0.05-0.2 in/hr. Suitability: good to poor. | Shearing strength: subsoil, very low; substrata, very low. Compacted permeability: semipervious to impervious. Compressibility: medium. May crack when dry. Stability: subsoil, moderate; substrata, low to moderate. Piping: low to high hazard. | Resistance to erosion, low to moderate. On cultivated slopes of 3-15%. Establishment of vegetation, fairly easy. |
| Ahl very gravelly silt loam | Stability: high. Compacted permeability: semipervious to impervious. Shrink-swell potential: low. Piping hazard through: fill - high hazard. | Permeability: subsoil, 0.8-2.5 in/hr; substratum, less than 0.05 in/hr. Basalt bedrock at 3 to 4 feet. | Shearing strength: subsoil, moderate; substratum, moderate. Compacted permeability: semipervious to impervious. Compressibility: very slight. Stability: subsoil, high; substratum, high. Piping: high hazard. Basalt bedrock at 3 to 4 feet. | Resistance to erosion, moderate. Establishment of vegetation, fairly difficult. |

Table 16. Soil features affecting engineering practices for water impoundments or disposal, Puget Sound Area (con.)

| Soil Series and Type | Dikes or Levees | Farm Ponds | | Terraces, Diversions and Waterways |
|---|---|---|---|---|
| | | Reservoir Area | Embankments | |
| Alderwood gravelly loam<br>Alderwood gravelly sandy loam<br>Alderwood fine sandy loam<br>Alderwood loamy sand<br>Alderwood silt loam<br>Alderwood loam<br>Alderwood stony loam | Stability: low.<br>Compacted permeability: semipervious to impervious.<br>Shrink-swell potential: low.<br>Piping hazard through: fill - high.<br>Suitability: good when compacted. | Permeability: subsoil, 0.8-2.5 in/hr; substrata, 0.05-0.2 in/hr.<br>Well suited.<br>Suitability: good to poor. | Shearing strength: subsoil, moderate; substrata, low.<br>Compacted permeability: semipervious to impervious.<br>Compressibility: slight.<br>Stability: subsoil, high; substrata, high.<br>Piping: high hazard. | Resistance to erosion, low to moderate.<br>On tilled slopes over 3%.<br>Establishment of vegetation, easy to fairly difficult. |
| Alluvial soils - undifferentiated | Stability: low.<br>Compacted permeability: semipervious to impervious.<br>Shrink-swell potential: moderate to high.<br>May crack when dry.<br>Piping hazard through: foundation - low to high, depending upon soil uniformity. Suitability: poor to very poor. | Permeability: subsoil, variable, 0.05-10.0 in/hr. substrata, variable, 0.05-10.0 in/hr. | Shearing strength: subsoil, very low; substrata, very low. Compacted permeability: semipervious to impervious.<br>Compressibility: medium to high. May crack when dry.<br>Stability: subsoil, low; substrata, low.<br>Piping: low to high, depending upon soil uniformity. | Resistance to erosion, low to moderate.<br>Establishment of vegetation, easy to difficult. |
| Astoria silt loam | Stability: moderate.<br>Compacted permeability: impervious. Cracks when dry.<br>Shrink-swell potential: moderate to high. Cracks when dry.<br>Piping hazard through: fill - low hazard.<br>Suitability: very poor. Cracks when dry. | Permeability: subsoil, 0.05-0.2 in/hr; substratum, 0.05-0.2 in/hr.<br>Shale or sandstone bedrock at 2.5 to 5 feet. | Shearing strength: subsoil, very low; substratum, very low. Compacted permeability: impervious. Cracks when dry.<br>Compressibility: medium to very high.<br>Stability: subsoil, moderate; substratum, moderate.<br>Piping: low hazard when wet. Cracks when dry. | Resistance to erosion, moderate.<br>Establishment of vegetation, fairly easy. |
| Barneston gravelly fine sandy loam<br>Barneston gravelly loamy sand<br>Barneston gravelly sandy loam | Stability: high.<br>Compacted permeability: pervious.<br>Shrink-swell potential: low.<br>Piping hazard through: fill - high to very high.<br>Not suitable. | Permeability: subsoil, 2.5-5.0 in/hr; substrata, 5.0-10.0 in/hr.<br>Not suitable. | Shearing strength: subsoil, moderate; substrata, very high.<br>Compacted permeability: pervious.<br>Compressibility: very slight.<br>Stability: subsoil, high; substrata, high. Piping: high to very high hazard. | Resistance to erosion, moderate to very high.<br>Establishment of vegetation, fairly difficult to difficult. |

Table 16. Soil features affecting engineering practices for water impoundments or disposal, Puget Sound Area (con.)

| Soil Series and Type | Dikes or Levees | Farm Ponds | | Terraces, Diversions and Waterways |
|---|---|---|---|---|
| | | Reservoir Area | Embankments | |
| Barneston silt loam<br>Barneston-Wilkeson* complex (*see Wilkeson silt loam for other interpretations) | Stability: low.<br>Compacted permeability: semipervious to impervious.<br>Shrink-swell potential: low.<br>Piping hazard through: fill - high.<br>Not suitable. | Permeability: subsoil, 2.5-5.0 in/hr; substrata, 5.0-10.0 in/hr.<br>Not suitable. | Shearing strength: subsoil, low; substrata, low.<br>Compacted permeability: semipervious to impervious.<br>Compressibility: very slight. to medium.<br>Stability: subsoil, low; substrata, low.<br>Piping: high hazard. | Resistance to erosion, low to moderate.<br>Establishment of vegetation, easy to fairly difficult.<br>Exception: Barneston-Wilkeson complex resistance to erosion, moderate to very high; establishment of vegetation, fairly difficult to difficult. |
| Barneston stony silt loam | Stability: high.<br>Compacted permeability: semipervious to impervious.<br>Shrink-swell potential: low.<br>Piping hazard through: fill - high.<br>Suitability: good to not suitable. | Permeability: subsoil, 2.5-5.0 in/hr; substratum, 5.0-10.0 in/hr.<br>Not suitable. | Shearing strength: subsoil, very high; substratum, very high.<br>Compacted permeability: semipervious to impervious.<br>Compressibility: very slight to medium.<br>Stability: subsoil, low; substratum, low.<br>Piping: high hazard. | Resistance to erosion, low to moderate.<br>Establishment of vegetation, easy to fairly difficult. |
| Barnhardt gravelly sandy loam | Stability: low.<br>Compacted permeability: semipervious to impervious.<br>Shrink-swell potential: low.<br>Piping hazard through: fill - high.<br>Suitability: fair when compacted with sheeps-foot roller. | Permeability: subsoil, 2.5-5.0 in/hr; substratum, 5.0-10.0 in/hr.<br>Over 10 feet, 0.05-0.2 in/hr. | Shearing strength: subsoil, low; substratum, low.<br>Compacted permeability: semipervious to impervious.<br>Compressibility: very slight.<br>Stability: subsoil, high; substratum, high.<br>Piping: high hazard. | Resistance to erosion, low to moderate.<br>Establishment of vegetation, fairly easy to fairly difficult. |
| Barnhardt gravelly silt loam | Stability: low to moderate.<br>Compacted permeability: impervious to semipervious.<br>Shrink-swell potential: low to moderate.<br>Piping hazard through: fill - high to low.<br>Suitability: fair when compacted with sheeps-foot roller. | Permeability: subsoil, 2.5-5.0 in/hr; substratum, 5.0-10.0 in/hr.<br>Not suitable. | Shearing strength: subsoil, very low; substratum, low.<br>Compacted permeability: semipervious to impervious.<br>Compressibility: medium to very slight.<br>Stability: subsoil, low; substratum, moderate to high.<br>Piping: high to low hazard. | Resistance to erosion, low to moderate.<br>Establishment of vegetation, fairly easy to fairly difficult. |

Table 16. Soil features affecting engineering practices for water impoundments or disposal, Puget Sound Area (con.)

| Soil Series and Type | Dikes or Levees | Farm Ponds | | Terraces, Diversions and Waterways |
|---|---|---|---|---|
| | | Reservoir Area | Embankments | |
| Belfast silt loam<br>Belfast silty clay loam | Stability: low. Compacted permeability: semipervious to impervious. Shrink-swell potential: high. Cracks when dry. Piping hazard through: foundation - variable, low to high; fill - low to high. Suitability: poor to very poor. Cracks when dry. | Permeability: subsoil, 0.2-0.8 in/hr; substrata, 0.2-0.8 in/hr. Suitability: good. | Shearing strength: subsoil, very low; substrata, very low. Compacted permeability: semipervious to impervious. Compressibility: very high. Stability: subsoil, low; substrata, low. Piping: low to high hazard. Cracks when dry. | Resistance to erosion, low. Establishment of vegetation, fairly easy. |
| Belfast fine sandy loam<br>Belfast sandy loam | Stability: low to moderate. Compacted permeability: semipervious to impervious. Shrink-swell potential: low to moderate. Piping hazard through: foundation - high to moderately low; fill - high to moderately low. Suitability: fair when compacted with sheeps-foot roller. | Permeability: subsoil, 0.8-2.5 in/hr; substrata, 2.5-5.0 in/hr. Suitability: good to poor. | Shearing strength: subsoil, low to very low; substrata, low. Compacted permeability: semipervious to impervious. Compressibility: very slight to medium. Stability: subsoil, low; substrata, low to moderate. Piping: high to low hazard. | Resistance to erosion, low to moderate. Establishment of vegetation, easy to fairly difficult. |
| Bellingham clay<br>Bellingham silty clay | Stability: moderate to low. Compacted permeability: semipervious to impervious. Shrink-swell potential: moderate. Piping hazard through: foundation - low to high; fill - low to high. Suitability: fair to very poor. Cracks when dry. | Permeability: subsoil, 0.05-0.2 in/hr; substrata, less than 0.05 in/hr. | Shearing strength: subsoil, very low; substrata, very low. Compacted permeability: semi-pervious to impervious. Compressibility: medium to high. Stability: subsoil, low to moderate; substrata, moderate. Piping: low to high hazard. Suitability: good to very poor. Cracks when dry. | Resistance to erosion, moderate. Establishment of vegetation, fairly easy. |
| Bellingham clay loam<br>Bellingham silty clay loam | Stability: low to moderate. Compacted permeability: semipervious to impervious. Shrink-swell potential: moderate to high. Piping hazard through: foundation - high to low; fill -variable, low to high. Suitability: fair to very poor when compacted with sheeps-foot or rubber-tired roller. May crack when dry. | Permeability: subsoil, 0.05-0.2 in/hr; substrata, less than 0.05 in/hr. Cracks when dry. | Shearing strength: subsoil, very low; substrata, very low. Compacted permeability: semipervious to impervious. Compressibility: medium to very high. Stability: subsoil, low; substrata, moderate to low. Piping: variable. Low to high hazard. | Resistance to erosion, low to moderate. Establishment of vegetation, fairly easy. |

Table 16. Soil features affecting engineering practices for water impoundments or disposal, Puget Sound Area (con.)

| Soil Series and Type | Dikes or Levees | Farm Ponds: Reservoir Area | Farm Ponds: Embankments | Terraces, Diversions and Waterways |
|---|---|---|---|---|
| Bellingham silt loam<br>Bellingham loam<br>Bellingham fine sandy loam | Stability: moderate to low.<br>Compacted permeability: impervious to semipervious.<br>Shrink-swell potential: moderate to high.<br>Piping hazard through: fill - low. Suitability: fair when compacted with sheeps-foot or rubber-tired roller. Cracks when dry. | Permeability: subsoil, 0.05-0.2 in/hr; substrata, less than 0.05 in/hr.<br>Cracks when dry. | Shearing strength: subsoil, very low; substrata, very low. Compacted permeability: impervious to semipervious.<br>Compressibility: high to very high.<br>Stability: subsoil, low to moderate; substrata, moderate. Piping: variable, low to high. Cracks when dry. | Resistance to erosion, moderate.<br>Establishment of vegetation, fairly easy. |
| Bow silt loam<br>Bow silt loam, shallow<br>Bow silty clay loam<br>Bow-Bellingham silty clay loams (see above for Bellingham) | Stability: moderate.<br>Compacted permeability: impervious.<br>Shrink-swell potential: moderate to high.<br>Piping hazard through: foundation - low; fill - low.<br>Suitability: good to fair when compacted with sheeps-foot or rubber-tired roller.<br>May crack when dry. | Permeability: subsoil, 0.05-0.2 in/hr; substrata, less than 0.05 in/hr.<br>Suitability: good.<br>May crack when dry. | Shearing strength: subsoil, very low; substrata, very low. Compacted permeability: impervious.<br>Compressibility: medium to high.<br>Stability: subsoil, moderate; substrata, moderate.<br>Piping: low to high hazard.<br>Cracks when dry. | Resistance to erosion, moderate.<br>On tilled slopes over 3%.<br>Establishment of vegetation, fairly easy. |
| Bow stony silt loam<br>Bow gravelly loam<br>Bow gravelly silt loam<br>Bow clay loam | Stability: low to moderate.<br>Compacted permeability: impervious to semipervious.<br>Shrink-swell potential: moderate to high.<br>Piping hazard through: fill - low.<br>Suitability: good to very poor. Cracks when dry. | Permeability: subsoil, 0.05-0.2 in/hr; substrata, less than 0.05 in/hr. | Shearing strength: subsoil, very low; substrata, very low. Compacted permeability: impervious to semipervious.<br>Compressibility: medium to very high.<br>Stability: subsoil, low to moderate; substrata, moderate. Piping: low hazard. | Resistance to erosion, moderate.<br>On tilled slopes over 3%.<br>Establishment of vegetation, fairly easy. |
| Bozarth fine sandy loam | Stability: low.<br>Compacted permeability: semipervious to impervious.<br>Shrink-swell potential: low.<br>Piping hazard through: fill - high.<br>Suitability: fair when compacted with sheeps-foot roller. | Permeability: subsoil, 0.8-2.5 in/hr; substratum, 0.05-0.2 in/hr.<br>Suitability: fair. | Shearing strength: subsoil, low, substratum, low.<br>Compacted permeability: semipervious to impervious.<br>Compressibility: very slight.<br>Stability: subsoil, low; substratum, low.<br>Piping: high hazard. | Resistance to erosion, low to moderate.<br>On tilled slopes over 3%.<br>Establishment of vegetation, difficult. |

Table 16. Soil features affecting engineering practices for water impoundments or disposal, Puget Sound Area (con.)

| Soil Series and Type | Dikes or Levees | Farm Ponds | | Terraces, Diversions and Waterways |
|---|---|---|---|---|
| | | Reservoir Area | Embankments | |
| Buckley clay loam<br>Buckley silt loam<br>Buckley loam<br>Buckley-Enumclaw* loams (*see Enumclaw loam) | Stability: low to moderate. Compacted permeability: semipervious to impervious. Shrink-swell potential: low to moderate. Piping hazard through: fill - mud. Low to high. Suitability: good to poor. | Permeability: subsoil, 0.8-2.5 in/hr; substrata, 0.05-0.2 in/hr. Suitability: fair to very good. | Shearing strength: subsoil, low; substrata, low. Compacted permeability: semipervious to impervious. Compressibility: very slight to medium. Stability: subsoil, low; substrata, low to moderate. Piping: high to moderately low hazard. | Resistance to erosion, moderately low. Establishment of vegetation, fairly easy to difficult. |
| Cagey sandy loam<br>Cagey gravelly loam<br>Cagey silt loam<br>Cagey silt loam-Norma* silty clay loam complex (*see Norma silty clay loam) | Stability: low to moderate. Compacted permeability: semipervious to pervious. Shrink-swell potential: low to very low. Piping hazard through: fill - high to very high. | Permeability: subsoil, 2.5-5.0 in/hr; substrata, less than 0.05 in/hr. Cemented gravelly sandy glacial till substrata at 4 to 6 feet. | Shearing strength: subsoil, low; substrata, high to very high. Compacted permeability: semipervious to pervious. Compressibility: very slight. Stability: subsoil, low; substrata, moderate. Piping: high to very high. | Resistance to erosion, low to moderate. On tilled slopes over 3%. Exception: Cagey sandy loam, 8%. Establishment of vegetation, easy to difficult. Exception: Cagey sandy loam, easy to fairly difficult. |
| Cagey gravelly sandy loam<br>Cagey fine sandy loam | Stability: low to moderate. Compacted permeability: semipervious to impervious. Shrink-swell potential: low to moderate. Piping hazard through: fill - low to high. Suitability: good to poor. | Permeability: subsoil, 2.5-5.0 in/hr; substrata, less than 0.05 in/hr. Suitability: good to poor. Cemented gravelly sandy glacial till at 4 to 6 feet. | Shearing strength: subsoil, low; substrata, very low. Compacted permeability: semipervious to impervious. Compressibility: very slight to medium. Stability: subsoil, low to moderate; substrata, moderate. Piping: low to high hazard. | Resistance to erosion, low to moderate. On tilled slopes over 8%. Establishment of vegetation, easy to fairly difficult. |
| Camas clay loam<br>Camas gravelly loam | Stability: moderate. Compacted permeability: impervious to pervious. Shrink-swell potential: moderate to low. Piping hazard through: fill - very high to low. Suitability: not suitable. | Permeability: subsoil, 0.2-0.8 in/hr; substrata, 5.0-10.0 in/hr. May be subject to periodic overflow. Suitability: good to very poor. | Shearing strength: subsoil, very low; substrata, high. Compacted permeability: impervious to pervious. Compressibility: subsoil, medium; substrata, very slight. Stability: subsoil, low to moderate; substrata, moderate. Piping: very high to low hazard. | Camas clay loam: Resistance to erosion, moderate; establishment of vegetation, easy. Camas gravelly loam: Resistance to erosion, low to moderate. Establishment of vegetation, fairly easy. |

Table 16. Soil features affecting engineering practices for water impoundments or disposal, Puget Sound Area (con.)

| Soil Series and Type | Dikes or Levees | Farm Ponds | | Terraces, Diversions and Waterways |
|---|---|---|---|---|
| | | Reservoir Area | Embankments | |
| Carbondale muck (McMurray) | Stability: unstable. Not suitable. Low strength. Compacted permeability: not suitable. Low volume weight. Shrink-swell potential: very high. Not suitable. Cracks when dry. Piping hazard through: foundation - not suitable; fill - not suitable. Remove from base. Not suitable. | Permeability: subsoil, 0.05-2.5 in/hr; substratum, less than 0.05 in/hr. Remove from foundation. | Shearing strength: subsoil, not suitable. Low volume weight. Low strength. | Resistance to erosion, low. Establishment of vegetation, easy. |
| Carbondale muck, shallow | Stability: unstable. Compacted permeability: not suitable. Cracks when dry. Low volume weight. Shrink-swell potential: very high. Piping hazard through: foundation - very high. Remove from foundation. Fill - not suitable. Low volume weight. Low strength. | Permeability: subsoil, 0.05-2.5 in/hr; substratum, 0.05-2.5 in/hr. Remove from foundation. | Not suitable. Low volume weight. Shrink-swell: high. Cracks when dry. | Resistance to erosion, low. Establishment of vegetation, easy to difficult. |
| Carlsborg gravelly loam<br>Carlsborg gravelly sandy loam | Stability: high to low. Compacted permeability: semipervious to impervious. Shrink-swell potential: low. Piping hazard through: fill - high hazard. | Permeability: subsoil, 2.5-5.0 in/hr; substrata, 2.5-5.0 in/hr. Not suitable. | Shearing strength: subsoil, low; substrata, moderate. Compacted permeability: semipervious to impervious. Compressibility: very slight to medium. Stability: subsoil, low; substrata, high. Piping: high hazard. | Resistance to erosion, low to moderate. Establishment of vegetation, easy to fairly difficult. |
| Carstairs gravelly loam | Stability: high. Compacted permeability: semipervious to pervious. Shrink-swell potential: low. Piping hazard through: fill - very high to high. Not suitable. | Permeability: subsoil, 5.0-10.0 in/hr; substratum, 5.0-10.0 in/hr. Not suitable. | Shearing strength: subsoil, low; substratum, low to moderate. Compacted permeability: semipervious to pervious. Compressibility: very slight to medium. Stability: subsoil, low; substratum, low to high. Piping: very high to high. | Resistance to erosion, moderate to high. Establishment of vegetation, difficult. |

Table 16. Soil features affecting engineering practices for water impoundments or disposal, Puget Sound Area (con.)

| Soil Series and Type | Dikes or Levees | Farm Ponds: Reservoir Area | Farm Ponds: Embankments | Terraces, Diversions and Waterways |
|---|---|---|---|---|
| Casey fine sandy loam | Stability: low. Compacted permeability: semipervious to impervious. Shrink-swell potential: low to moderate. Piping hazard through: fill - high. Suitability: poor. | Permeability: subsoil, less than 0.05 in/hr; substratum, less than 0.05 in/hr. Loose, sandy and gravelly glacial material at 2 to 3 feet. Suitability: poor. | Shearing strength: subsoil, low; substratum, very low. Compacted permeability: semipervious to impervious. Compressibility: medium to very slight. Stability: subsoil, low; substratum, low. Piping: high hazard. | Resistance to erosion, moderate to high. On tilled lands with slopes above 3%. Establishment of vegetation, easy to fairly difficult. |
| Casey loam<br>Casey silt loam | Stability: moderate to low. Compacted permeability: impervious to semipervious. Shrink-swell potential: high to low. Piping hazard through: fill - low to high. Suitability: good to poor. | Permeability: subsoil, less than 0.05 in/hr; substrata, less than 0.05 in/hr. Loose, sandy and gravelly glacial material at 4 to 6 feet. Suitability: poor. | Shearing strength: subsoil, very low; substrata, low. Compacted permeability: impervious to semipervious. Compressibility: very high to very slight. Stability: subsoil, moderate; substrata, low. Piping: low to high. | Resistance to erosion, moderate to high. On tilled lands with slopes above 3%. Establishment of vegetation, easy to fairly difficult. |
| Cathcart loam<br>Cathcart gravelly loam<br>Cathcart gravelly silt loam<br>Cathcart fine sandy loam<br>Cathcart stony loam | Stability: low to high. Compacted permeability: semipervious to impervious. Shrink-swell potential: low to moderate. Piping hazard through: fill - moderately low to high. Suitability: good to poor when compacted with sheepsfoot roller. | Permeability: subsoil, 0.8-2.5 in/hr; substrata, 0.05-0.2 in/hr. Sandstone bedrock at 24 to 60 inches. Suitability: good. | Shearing strength: subsoil, low; substrata, moderate. Compacted permeability: semipervious to impervious. Compressibility: very slight to medium. Stability: subsoil, low; substrata, high. Piping: moderately low to high. | Resistance to erosion, low to moderate. On tilled land with slopes above 3%. Establishment of vegetation, easy to fairly difficult. |
| Chehalis loam<br>Chehalis silt loam | Stability: low. Compacted permeability: semipervious to impervious. Shrink-swell potential: low. Piping hazard through: foundation - high. fill - high. Suitability: good to poor when compacted with sheepsfoot roller. | Permeability: subsoil, 0.8-2.5 in/hr; substrata, 0.8-2.5 in/hr. Suitability: fair. | Shearing strength: subsoil, low; substrata, low. Compacted permeability: semipervious to impervious. Compressibility: very slight to medium. Stability: subsoil, low; substrata, low. Piping: high hazard. | Resistance to erosion, low to moderate. Establishment of vegetation, easy. |

Table 16. Soil features affecting engineering practices for water impoundments or disposal, Puget Sound Area (con.)

| Soil Series and Type | Dikes or Levees | Farm Ponds | | Terraces, Diversions and Waterways |
|---|---|---|---|---|
| | | Reservoir Area | Embankments | |
| Chehalis silt loam, mottled<br>Chehalis silty clay loam | Stability: moderate.<br>Compacted permeability: impervious.<br>Shrink-swell potential: high.<br>Piping hazard through: foundation - low to high; fill - low.<br>Suitability: very poor.<br>Cracks when dry. | Permeability: subsoil, 0.8-2.5 in/hr; substrata, 0.8-2.5 in/hr.<br>Suitability: good to fair.<br>Cracks when dry. | Shearing strength: subsoil, very low; substrata, very low.<br>Compacted permeability: impervious.<br>Compressibility: slight to very high.<br>Stability: subsoil, moderate; substrata, moderate.<br>Piping: low to high hazard. | Resistance to erosion, moderate to high.<br>Establishment of vegetation, fairly easy. |
| Chimacum gravelly sandy loam | Stability: low to moderate.<br>Compacted permeability: semipervious to pervious.<br>Shrink-swell potential: low.<br>Piping hazard through: fill - high to very high.<br>Suitability: fair to not suitable. | Permeability: subsoil, 5.0-10.0 in/hr; substratum, 5.0-10.0 in/hr.<br>Suitability: fair to not suitable. | Shearing strength: subsoil, low: substratum, high.<br>Compacted permeability: semipervious to pervious.<br>Compressibility: very slight.<br>Stability: subsoil, low; substratum, moderate.<br>Piping: high to very high hazard. | Resistance to erosion, low to moderate.<br>Establishment of vegetation, difficult. |
| Chimacum gravelly loamy sand<br>Chimacum very gravelly loamy sand | Stability: low to high.<br>Compacted permeability: very pervious to impervious<br>Shrink-swell potential: low.<br>Piping hazard through: fill - high to very high.<br>Suitability: fair to not suitable. | Permeability: subsoil, 5.0-10.0 in/hr; substrata, 5.0-10.0 in/hr.<br>Not suitable. | Shearing strength: subsoil, low, substrata; moderate to high.<br>Compacted permeability: very pervious to impervious.<br>Compressibility: very slight.<br>Stability: subsoil, low; substrata, high to moderate.<br>Piping: high to very high hazard. | Resistance to erosion, moderate.<br>Establishment of vegetation, difficult. |
| Cinebar silt loam | Stability: low.<br>Compacted permeability: semipervious to impervious.<br>Shrink-swell potential: moderate to low.<br>Piping hazard through: fill - high.<br>Poorly suited. | Permeability: subsoil, 0.8-2.5 in/hr; substratum, 0.05-0.2 in/hr.<br>Poorly suited. | Shearing strength: subsoil, very low; substratum, very low.<br>Compacted permeability: semipervious to impervious.<br>Compressibility: medium.<br>Stability: subsoil, low; substratum, low.<br>Piping: high hazard. | Resistance to erosion, low.<br>Establishment of vegetation, easy. |

Table 16. Soil features affecting engineering practices for water impoundments or disposal, Puget Sound Area (con.)

| Soil Series and Type | Dikes or Levees | Farm Ponds | | Terraces, Diversions and Waterways |
|---|---|---|---|---|
| | | Reservoir Area | Embankments | |
| Cispus pumicy sandy loam | Stability: moderately low. Compacted permeability: pervious to semipervious. Shrink-swell potential: low. Piping hazard through: fill - high to very high hazard. | Permeability: subsoil, 2.5-5.0 in/hr; substratum, 0.2-0.8 in/hr. | Shearing strength: subsoil, high to low; substratum, low. Compacted permeability: pervious to semipervious. Compressibility: very slight to medium. Stability: subsoil, moderate to low; substratum, low. Piping: high to very high hazard. | Resistance to erosion, low. Establishment of vegetation, fairly difficult. May apply when land is cleared for development. |
| Clackamas silty clay loam | Stability: moderate. Compacted permeability: impervious. Shrink-swell potential: high. Piping hazard through: fill - low. Suitability: poor to very poor. Cracks when dry. | Permeability: subsoil, less than 0.05 in/hr; substratum, 0.05-0.2 in/hr. Suitability: good. Cracks when dry. | Shearing strength: subsoil, very low; substratum, very low. Compacted permeability: impervious. Compressibility: very high to high. Stability: subsoil, low; substratum, moderate. Piping: low hazard. | Resistance to erosion, moderate to high. Will apply on land above 3% slopes. Establishment of vegetation, fairly difficult. |
| Clallam gravelly loam<br>Clallam loam | Stability: low. Compacted permeability: semipervious to impervious. Shrink-swell potential: low. Piping hazard through: fill - high. Suitability: good when packed with sheeps-foot roller. | Permeability: subsoil, 0.2-0.8 in/hr; substrata, less than 0.05 in/hr. Well suited. Cemented gravelly loam glacial till at 3 to 4 feet. | Shearing strength: subsoil, low, substrata, low. Compacted permeability: semipervious to impervious. Compressibility: very slight to medium. Stability: subsoil, low; substrata, high. Cemented glacial till. | Resistance to erosion, low to moderate. On tilled land above 3% slopes. Establishment of vegetation, difficult. |
| Clallam gravelly sandy loam | Stability: low to moderate. Compacted permeability: semipervious to impervious. Shrink-swell potential: low to moderate. Piping hazard through: fill - moderately low to high. Suitability: good to fair when compacted with sheeps-foot roller. | Permeability: subsoil, 0.2-0.8 in/hr; substratum, less than 0.05 in/hr. Cemented gravelly loam glacial till at 3 to 4 feet. Well suited. | Shearing strength: subsoil, low; substratum, low. Compacted permeability: semipervious to impervious. Compressibility: slight to very slight. Stability: subsoil, low; substratum, moderate to low. Piping: low to high hazard. | Resistance to erosion, low to moderate. On tilled land above 3% slopes. Establishment of vegetation, difficult. |

Table 16. Soil features affecting engineering practices for water impoundments or disposal, Puget Sound Area (con.)

| Soil Series and Type | Dikes or Levees | Farm Ponds | | Terraces, Diversions and Waterways |
|---|---|---|---|---|
| | | Reservoir Area | Embankments | |
| Clipper silty clay loam | Stability: low to moderate. Compacted permeability: impervious to pervious. Shrink-swell potential: low to very low. Piping hazard through: fill - high to very high. | Permeability: subsoil, less than 0.05 in/hr; substratum, 0.05-0.2 in/hr. Not suitable. Sands at 10 to 20 inches. | Shearing strength: subsoil, low, substratum, high to very high. Compacted permeability: impervious to pervious. Compressibility: very slight. Stability: subsoil, low; substratum, moderate. Piping: high to very high. | Resistance to erosion, low to moderate. Establishment of vegetation, fairly difficult to difficult. |
| Cloquallum silt loam | Stability: moderate to low. Compacted permeability: impervious to semipervious. Shrink-swell potential: moderate to low. Piping hazard through: fill - low to high. Suitability: fair to poor when compacted with sheeps-foot roller. Cracks when dry. | Permeability: subsoil, 0.2-0.8 in/hr; substratum, 0.05-0.2 in/hr. Suitability: good to fair. | Shearing strength: subsoil, very low; substratum, very low. Compacted permeability: impervious to semipervious. Compressibility: medium to high. Stability: subsoil, moderate; substratum, moderate to low. Piping: low to high. | Resistance to erosion, moderately low. On tilled land with slopes over 3%. Establishment of vegetation, fairly easy. |
| Cloquallum silt loam, shallow over till | Stability: low to high. Compacted permeability: semipervious to impervious. Shrink-swell potential: low to moderate. May crack when dry. Piping hazard through: fill - high hazard. Good when compacted with sheeps-foot roller. | Permeability: subsoil, 0.2-0.8 in/hr; substratum, 0.05-0.2 in/hr. Fair to good site. | Shearing strength: subsoil, very low; substratum, low to moderate. Compacted permeability: semipervious to impervious. Compressibility: very slight to medium. May crack when dry. Stability: subsoil, moderate; substratum, low to high. Piping: high hazard. | Resistance to erosion, moderately low. On tilled land with slopes over 3%. Establishment of vegetation, fairly easy. |
| Cloquallum silty clay loam | Stability: low to moderate. Compacted permeability: semipervious to impervious. May crack when dry. Shrink-swell potential: moderate to low. Piping hazard through: fill - high to low. Suitability: good to poor when compacted with sheeps-foot roller. | Permeability: subsoil, 0.2-0.8 in/hr; substratum, 0.05-0.2 in/hr. Good to poor site. | Shearing strength: subsoil, very low; substratum, very low. Compacted permeability: semipervious to impervious. May crack when dry. Compressibility: medium to low. Stability: subsoil, low; substratum, low to moderate. Piping: high to low hazard. | Resistance to erosion, moderately low. On tilled land with slopes over 3%. Establishment of vegetation, fairly easy. |

Table 16. Soil features affecting engineering practices for water impoundments or disposal, Puget Sound Area (con.)

| Soil Series and Type | Dikes or Levees | Farm Ponds | | Terraces, Diversions and Waterways |
|---|---|---|---|---|
| | | Reservoir Area | Embankments | |
| Coastal beach | Stability: high.<br>Compacted permeability: very pervious.<br>Shrink-swell potential: low.<br>Piping hazard through: foundation - very high; fill - very high. | Permeability: subsoil, 5.0-10.0 in/hr; substrata, 5.0-10.0 in/hr.<br>Not suitable. | Shearing strength: subsoil, high; substrata, high.<br>Compacted permeability: very pervious.<br>Compressibility: very slight.<br>Stability: subsoil, high; substrata, high.<br>Piping: very high hazard. | Resistance to erosion, low.<br>Establishment of vegetation, difficult. |
| Cokedale loam<br>Cokedale silt loam | Stability: low.<br>Compacted permeability: semipervious to impervious.<br>Shrink-swell potential: moderate to low.<br>Piping hazard through: fill - high.<br>Suitability: poor because of uniform particle size. | Permeability: subsoil, 0.05-0.2 in/hr; substrata, 0.2-0.8 in/hr.<br>Suitability: high hazard because of seepage. | Shearing strength: subsoil, very low; substrata, very low.<br>Compacted permeability: semipervious to impervious.<br>Compressibility: very slight to medium.<br>Stability: subsoil, low; substrata, low.<br>Piping: high hazard. | Resistance to erosion, low.<br>Establishment of vegetation, easy. |
| Cokedale sandy loam<br>Cokedale silt loam/ Puyallup<br>Cokedale silty clay loam<br>Cokedale silty clay loam/Puyallup | Stability: low to moderate.<br>Compacted permeability: impervious to pervious.<br>Shrink-swell potential: low to very low.<br>Piping hazard through: foundation - high to very high;<br>fill - high to very high.<br>Suitability; poor. | Permeability: subsoil, 0.05-0.2 in/hr; substrata, Variable, 0.05-2.5 in/hr.<br>Suitability: high hazard because of seepage. | Shearing strength: subsoil, very low; substrata, low to very high.<br>Compacted permeability: impervious to pervious.<br>Compressibility: very slight to medium.<br>Stability: subsoil, low; substrata, low to moderate.<br>Piping: high to very high hazard. | Resistance to erosion, low.<br>Establishment of vegetation, easy to difficult.<br>Exception, Cokedale silty clay loam/Puyallup--establishment of vegetation, easy to fairly difficult. |
| Colvos fine sandy loam | Stability: low.<br>Compacted permeability: semipervious to impervious.<br>Shrink-swell potential: low.<br>Piping hazard through: fill - high.<br>Suitability: good to poor when compacted with sheepsfoot roller. | Permeability: subsoil, 0.8-2.5 in/hr; substratum, 0.05-0.2 in/hr.<br>Suitability: unsuited. | Shearing strength: subsoil, low; substratum, low.<br>Compacted permeability: semipervious to impervious.<br>Compressibility: very slight to medium.<br>Stability: subsoil, low; substratum, low.<br>Piping: high hazard. | Resistance to erosion, low.<br>On cleared land with slopes over 8%.<br>Establishment of vegetation, fairly difficult. |

Table 16. Soil features affecting engineering practices for water impoundments or disposal, Puget Sound Area (con.)

| Soil Series and Type | Dikes or Levees | Farm Ponds: Reservoir Area | Farm Ponds: Embankments | Terraces, Diversions and Waterways |
|---|---|---|---|---|
| Colvos fine sandy loam/Everett * gravelly sandy loam complex (*see Everett gravelly sandy loam for additional interpretations) | Stability: low to high. Compacted permeability: semipervious to impervious. Shrink-swell potential: low. Piping hazard through: fill - high. Suitability: good to poor when compacted with sheepsfoot roller. | Permeability: subsoil, 0.8-2.5 in/hr; substrata, 0.05-0.2 in/hr. Suitability: fairly well suited on Colvos soils. Unsuited on Everett soils. | Shearing strength: subsoil, low; substrata, low to moderate. Compacted permeability: semipervious to impervious. Compressibility: very slight to medium. Stability: subsoil, low; substrata, high. Piping: high hazard. | Resistance to erosion, low. On cleared land with slopes over 8%. Establishment of vegetation, fairly difficult. |
| Colvos fine sandy loam/Kitsap * silt loam complex (*see Kitsap silt loam for additional interpretations) | Stability: low. Compacted permeability: semipervious to impervious. Shrink-swell potential: moderate to low. Piping hazard through: fill - high. Suitability: good to poor when compacted with sheepsfoot roller. | Permeability: subsoil, 0.8-2.5 in/hr; substrata, 0.05-0.2 in/hr. Suitability: fair to poor. | Shearing strength: subsoil, very low; substrata, very low to low. Compacted permeatiliby: semipervious to impervious. Compressibility: very slight to medium. Stability: subsoil, low; substrata, low. Piping: high hazard. | Resistance to erosion, low. On cleared land with slopes over 8%. Establishment of vegetation, fairly difficult. |
| Corkindale loam | Stability: low. Compacted permeability: semipervious to impervious. Shrink-swell potential: moderate to low. Piping hazard through: fill - high. Suitability: good to poor when compacted with sheepsfoot roller. | Permeability: subsoil, 0.8-2.5 in/hr; substratum, 5.0-10.0 in/hr. Suitability: poor because of substratum rapid permeability. | Shearing strength: subsoil, very low; substratum, low. Compacted permeability: semipervious to impervious. Compressibility: very slight to medium. Stability: subsoil, low; substratum, low. Piping: high hazard. | Resistance to erosion, low. On cleared areas over 8%. Establishment of vegetation, fairly difficult. |
| Coupeville loam | Stability: moderate. Compacted permeability: impervious. Cracks when dry. Shrink-swell potential: low to high. Piping hazard through: fill - moderately low to low. Suitability: fair to poor when compacted with sheepsfoot roller. | Permeability: subsoil, 0.2-0.8 in/hr; substratum, 0.05-0.2 in/hr. Suitability: very poor. Substratum cracks when dry. | Shearing strength: subsoil, low; substratum, very low. Compacted permeability: impervious. Cracks when dry. Compressibility: slight to very high. Stability: subsoil, moderate; substratum, moderate. Piping: moderately low to low hazard. | Resistance to erosion, moderate. Establishment of vegetation, fairly difficult. |

Table 16. Soil features affecting engineering practices for water impoundments or disposal, Puget Sound Area (con.)

| Soil Series and Type | Dikes or Levees | Farm Ponds | | Terraces, Diversions and Waterways |
|---|---|---|---|---|
| | | Reservoir Area | Embankments | |
| Coupeville silt loam | Stability: moderate. Compacted permeability: impervious. Cracks when dry. Shrink-swell potential: moderate. Cracks when dry. Piping hazard through: fill - low. Suitability: good when compacted with sheeps-foot or rubber-tired roller. | Permeability: subsoil, 0.2-0.8 in/hr; substratum, 0.05-0.2 in/hr. Suitability: poor. Cracks when dry. | Shearing strength: subsoil, very low; substratum, very low. Compacted permeability: impervious. Cracks when dry. Compressibility: medium to high. Stability: subsoil, moderate; substratum, moderate. Piping: low hazard. | Resistance to erosion, moderate. Establishment of vegetation, fairly difficult. |
| Coveland gravelly loam<br>Coveland gravelly silt loam | Stability: low to moderate. Compacted permeability: semipervious to impervious. Shrink-swell potential: subsoil, moderate to low; substrata, moderate to high. Piping hazard through: fill - high hazard to low hazard. Very poor compaction qualities. | Permeability: subsoil, 0.05-0.2 in/hr; substrata, less than 0.05 in/hr. Good to very poor site. Cracks when dry. | Shearing strength: subsoil, low to very low; substrata, very low. Compacted permeability: semipervious to impervious. Compressibility: very slight to very high. Stability: subsoil, low; substrata, moderate. Piping: high hazard because of poor compaction qualities. | Resistance to erosion, low to moderate. On clean tilled slopes above 3%. Establishment of vegetation, fairly difficult. |
| Coveland silt loam | Stability: low to moderate. Compacted permeability: semipervious to impervious. Shrink-swell potential: low to moderate. Piping hazard through: fill - high to moderately low. Suitability: good to poor when compacted with sheeps-foot roller. | Permeability: subsoil, 0.05-0.2 in/hr; substratum, less than 0.05 in/hr. Suitability: very good to fair. | Shearing strength: subsoil, low, substratum, low. Compacted permeability: semipervious to impervious. Compressibility: very slight to medium. Stability: subsoil, low; substratum, low to moderate. Piping: high to moderately low hazard. | Resistance to erosion, low. On cleared tilled slopes above 3%. Establishment of vegetation, fairly difficult. |
| Coveland loam | Stability: low to moderate. Compacted permeability: semipervious to impervious. Cracks when dry. Shrink-swell potential: low to moderate. Piping hazard through: fill - high to low, when compacted with sheeps-foot roller. | Permeability: subsoil, 0.05-0.2 in/hr; substratum, less than 0.05 in/hr. Suitability: fair to good. | Shearing strength: subsoil, low; substratum, very low. Compacted permeability: semipervious to impervious. Compressibility: very slight to high. Stability: subsoil, low; substratum, low to moderate. Piping: high to low hazard. | Resistance to erosion, low. On cleared tilled slopes above 3%. Establishment of vegetation, fairly difficult. |

Table 16. Soil features affecting engineering practices for water impoundments or disposal, Puget Sound Area (con.)

| Soil Series and Type | Dikes or Levees | Farm Ponds | | Terraces, Diversions and Waterways |
|---|---|---|---|---|
| | | Reservoir Area | Embankments | |
| Coveland stony silt loam | Stability: low to moderate. Compacted permeability: semipervious to impervious. May crack when dry. Shrink-swell potential: low to high. Piping hazard through: fill - high to low. Suitability: good to very poor because of compaction properties. | Permeability: subsoil, 0.05-0.2 in/hr; substratum, less than 0.05 in/hr. | Shearing strength: subsoil, low; substratum, very low. Compacted permeability: semipervious to impervious. Compressibility: very slight to very high. Stability: subsoil, low to moderate; substratum, moderate. Piping: high to low hazard. | Resistance to erosion, low to moderate. On clean tilled slopes above 3%. Establishment of vegetation, fairly difficult. |
| Crescent gravelly loam | Stability: high. Compacted permeability: semipervious to impervious. Shrink-swell potential: low. Piping hazard through: fill - high. | Permeability: subsoil, 2.5-5.0 in/hr; substratum, 5.0-20.0 in/hr. Suitability: not suitable because of rapid permeability. | Shearing strength: subsoil, moderate; substratum, moderate. Compacted permeability: semipervious to impervious. Compressibility: very slight. Stability: subsoil, moderate; substratum, moderate. Piping: high hazard. | Resistance to erosion, moderate. Establishment of vegetation, difficult. |
| Custer sandy loam<br>Custer fine sandy loam<br>Custer silt loam | Stability: low to moderate. Compacted permeability: pervious to impervious. Shrink-swell potential: low. Piping hazard through: fill - very high. | Permeability: subsoil, 0.05-0.2 in/hr; substrata, 0.05-0.2 in/hr. Not suitable. | Shearing strength: subsoil, low to high; substrata, low to high. Compacted permeability: pervious to impervious. Compressibility: very slight to medium. Stability: subsoil, low to moderate; substrata, low to moderate. Piping: very high hazard. | Resistance to erosion, low. Establishment of vegetation, easy to fairly difficult. |
| Dabob very gravelly sandy loam | Stability: high to low. Compacted permeability: pervious to impervious. Shrink-swell potential: low. Piping hazard through: fill - high to very high. Suitability: good when compacted with sheeps-foot roller | Permeability: subsoil, 2.5-5.0 in/hr; substratum, 0.05-0.2 in/hr. Suitability: well suited. | Shearing strength: subsoil, moderate to low; substratum; low to high. Compacted permeability: pervious to impervious. Compressibility: very slight. Stability: subsoil, low to high; substratum, low to moderate. Piping: high hazard. | Resistance to erosion, moderate. Soil mantle, 2 to $2\frac{1}{2}$ feet. Establishment of vegetation, difficult. |

Table 16. Soil features affecting engineering practices for water impoundments or disposal, Puget Sound Area (con.)

| Soil Series and Type | Dikes or Levees | Farm Ponds | | Terraces, Diversions and Waterways |
|---|---|---|---|---|
| | | Reservoir Area | Embankments | |
| Delphi gravelly loam | Stability: high to low.<br>Compacted permeability: semipervious to impervious.<br>Shrink-swell potential: low.<br>Piping hazard through: fill - good to poor when compacted with sheeps-foot roller. | Permeability: subsoil, 0.2-0.8 in/hr; substratum, 0.05-0.2 in/hr.<br>Suitability: good. Cemented glacial till at 2½ to 3½ ft. | Shearing strength: subsoil, moderate, substratum, low to moderate.<br>Compacted permeability: semipervious to impervious.<br>Compressibility: very slight to medium.<br>Stability: subsoil, high; substratum, low to high.<br>Piping: high hazard. | Resistance to erosion, low to moderate.<br>Cleared areas over 3% slope.<br>Establishment of vegetation depends on soil depth, fairly difficult. |
| Dick loamy fine sand<br>Dick loamy sand<br>Dick loamy sand/Chimacum* gravelly loamy sand complex (*see Chimacum gravelly loamy sand) | Stability: low.<br>Compacted permeability: pervious.<br>Shrink-swell potential: low.<br>Piping hazard through: fill - high.<br>Suitability: good when compacted with crawler tractor or steel-wheeled roller. | Permeability: subsoil, 5.0-10.0 in/hr; substrata, 5.0-10.0 in/hr.<br>Suitability: not suitable. | Shearing strength: subsoil, low; substrata, low.<br>Compacted permeability: pervious.<br>Compressibility: very slight to medium.<br>Stability: subsoil, low; substrata, low.<br>Piping: high hazard. | Resistance to erosion, low.<br>On tilled slopes above 8%.<br>Establishment of vegetation, fairly difficult to difficult. |
| Discovery Bay gravelly sandy loam<br>Discovery Bay very gravelly sandy loam<br>Discovery Bay/Alderwood* gravelly sandy loams (*see Alderwood)<br>Discovery Bay/Hoodsport* gravelly sandy loams complex (*see Hoodsport)<br>Discovery Bay/Rock outcrop* complex (*see Rock outcrop) | Stability: high.<br>Compacted permeability: impervious to very pervious.<br>Shrink-swell potential: low.<br>Piping hazard through: fill - very high. | Permeability: subsoil, 2.5-5.0 in/hr; substrata, 0.8-2.5 in/hr.<br>Basalt bedrock at 30 to 50". | Shearing strength: subsoil, high to moderate; substrata, high to moderate.<br>Compacted permeability: impervious to very pervious.<br>Compressibility: very slight.<br>Stability: subsoil, high; substrata, high.<br>Piping: high hazard. | Resistance to erosion, moderate to high.<br>On cleared slopes over 8%.<br>Establishment of vegetation, difficult. |
| Dungeness loam<br>Dungeness silt loam | Stability: low.<br>Compacted permeability: semipervious to impervious.<br>Shrink-swell potential: moderate to low.<br>Piping hazard through: foundation - high; fill - high.<br>Suitability: good to poor when compacted with sheeps-foot roller. | Permeability: subsoil, 0.8-2.5 in/hr; substrata, 5.0-10.0 in/hr.<br>Suitability: poor to fair. | Shearing strength: subsoil, very low to low; substrata, low.<br>Compacted permeability: semipervious to impervious.<br>Compressibility: very slight to medium.<br>Stability: subsoil, low; substrata, low.<br>Piping: high hazard. | Resistance to erosion, low.<br>Establishment of vegetation, easy. |

Table 16. Soil features affecting engineering practices for water impoundments or disposal, Puget Sound Area (con.)

| Soil Series and Type | Dikes or Levees | Farm Ponds | | Terraces, Diversions and Waterways |
|---|---|---|---|---|
| | | Reservoir Area | Embankments | |
| Dungeness fine sandy loam<br>Dungeness fine sandy loam, shallow | Stability: low.<br>Compacted permeability: semipervious to impervious.<br>Shrink-swell potential: low.<br>Piping hazard through: foundation - high; fill - high.<br>Suitability: good to poor when compacted with sheepsfoot roller. | Permeability: subsoil, 0.8-2.5 in/hr; substrata, 5.0-10.0 in/hr.<br>Not suitable. | Shearing strength: subsoil, low; substrata, low.<br>Compacted permeability: semipervious to impervious.<br>Compressibility: very slight to medium.<br>Stability: subsoil, low; substrata, low.<br>Piping: high hazard. | Resistance to erosion, low.<br>Establishment of vegetation, easy. |
| Dupont muck | Stability: very low.<br>Compacted permeability: --<br>Shrink-swell potential: very high.<br>Piping hazard through: foundation - very high; fill - very high. Remove from foundation, not suitable. | Permeability: subsoil, 0.2-0.8 in/hr; substratum, 0.05-0.2 in/hr. | Shearing strength: subsoil -- Not suitable. Low volume weight. Low strength. Subject to shrinking and settling. | Resistance to erosion, low.<br>Establishment of vegetation, easy. |
| Ebeys sandy loam | Stability: moderate to low.<br>Compacted permeability: pervious to impervious.<br>Shrink-swell potential: very low to low.<br>Piping hazard through: fill - very high.<br>Suitability: good to poor when compacted with sheepsfoot roller. | Permeability: subsoil, 0.8-2.5 in/hr; substratum, 5.0-10.0 in/hr.<br>Suitability: fair to not suitable. | Shearing strength: subsoil, low; substratum, high.<br>Compacted permeability: pervious to impervious.<br>Compressibility: very slight to medium.<br>Stability: subsoil, low; substratum, moderate.<br>Piping: very high hazard. | Resistance to erosion, low.<br>Establishment of vegetation, fairly difficult to difficult. |
| Edgewick fine sandy loam<br>Edgewick silt loam<br>Edgewick very fine sandy loam<br>Edgewick sand<br>Edgewick sandy loam | Stability: low to high.<br>Compacted permeability: pervious to impervious.<br>Shrink-swell potential: moderate to low.<br>Piping hazard through: foundation - very high; fill - very high.<br>Suitability: good when compacted with crawler tractor or steel-wheeled roller. | Permeability: subsoil, 0.8-2.5 in/hr; substrata, 5.0-10.0 in/hr.<br>Suitability: not suitable. | Shearing strength: subsoil, low to very low; substrata, very high.<br>Compacted permeability: pervious to impervious.<br>Compressibility: very slight to medium.<br>Stability: subsoil, low; substrata, high.<br>Piping: very high. | Resistance to erosion, moderate to high.<br>Establishment of vegetation, easy to difficult. |

Table 16. Soil features affecting engineering practices for water impoundments or disposal, Puget Sound Area (con.)

| Soil Series and Type | Dikes or Levees | Farm Ponds | | Terraces, Diversions and Waterways |
|---|---|---|---|---|
| | | Reservoir Area | Embankments | |
| Edmonds sandy loam<br>Edmonds silt loam<br>Edmonds loam<br>Edmonds/Tromp* silt loams<br>Edmonds fine sandy loam (*see Tromp silt loam) | Stability: low to moderate.<br>Compacted permeability: pervious to impervious.<br>Shrink-swell potential: low.<br>Piping hazard through: fill - high to very high.<br>Suitability: good to poor when compacted with sheepsfoot roller. | Permeability: subsoil, Variable, 0.05-5.0 in/hr; substrata, 0.05-0.2 in/hr.<br>Suitability: not suitable. | Shearing strength: subsoil, low; substrata, low to high.<br>Compacted permeability: pervious to impervious.<br>Compressibility: very slight to medium.<br>Stability: subsoil, low; substrata, moderate to low.<br>Piping: very high hazard. | Resistance to erosion, low.<br>Establishment of vegetation, fairly difficult. |
| Eld loam<br>Eld gravelly loam<br>Eld silty clay loam | Stability: low.<br>Compacted permeability: semipervious to impervious.<br>Shrink-swell potential: moderate to high.<br>Piping hazard through: foundation - low to high; fill - low to high.<br>Stability: poor. | Permeability: subsoil, 0.2-0.8 in/hr; substratum, 0.2-0.8 in/hr.<br>Suitability: good. | Shearing strength: low.<br>Compacted permeability: semipervious to impervious.<br>Compressibility: medium.<br>Stability: low.<br>Piping: high hazard. | Resistance to erosion, moderate.<br>Establishment of vegetation, easy. |
| Elwha loam | Stability: low to moderate.<br>Compacted permeability: semipervious to impervious.<br>Shrink-swell potential: moderate to low. May crack when dry.<br>Piping hazard through: fill - low to high.<br>Suitability: good to poor when compacted with sheepsfoot roller. | Permeability: subsoil, 0.05-0.2 in/hr; substratum, less than 0.05 in/hr.<br>Suitability: good to poor.<br>May crack when dry. | Shearing strength: subsoil, very low; substratum, very low.<br>Compacted permeability: semipervious to impervious.<br>Compressibility: medium to high. May crack when dry.<br>Stability: subsoil, low to moderate; substratum, low to moderate. | Resistance to erosion, low.<br>Establishment of vegetation, easy. |
| Enumclaw loam<br>Enumclaw fine sandy loam<br>Enumclaw gravelly sandy loam | Stability: low.<br>Compacted permeability: semipervious to impervious.<br>Shrink-swell potential: low.<br>Piping hazard through: fill - high.<br>Suitability: good to poor when compacted with sheepsfoot roller. | Permeability: subsoil, 0.2-0.8 in/hr; substrata, 0.05-0.2 in/hr.<br>Suitability: fair to poor. | Shearing strength: subsoil, low; substrata, low.<br>Compacted permeability: semipervious to impervious.<br>Compressibility: very slight to medium.<br>Stability: subsoil, low to moderate; substrata, low to moderate.<br>Piping: high hazard. | Resistance to erosion, low.<br>Establishment of vegetation, fairly difficult. |

Table 16. Soil features affecting engineering practices for water impoundments or disposal, Puget Sound Area (con.)

| Soil Series and Type | Dikes or Levees | Farm Ponds | | Terraces, Diversions and Waterways |
|---|---|---|---|---|
| | | Reservoir Area | Embankments | |
| Everett gravelly sandy loam<br>Everett gravelly loamy sand<br>Everett stony sandy loam<br>Everett stony loamy sand | Stability: high. Compacted permeability: pervious to semipervious. Shrink-swell potential: low. Piping hazard through: fill - very high to high. Suitability: good when compacted with crawler tractor or steel-wheeled roller. | Permeability: subsoil, 5.0-10.0 in/hr; substrata, 5.0-10.0 in/hr. Not suitable. | Shearing strength: subsoil, very high; substrata, very high to moderate. Compacted permeability: pervious to semipervious. Compressibility: very slight. Stability: subsoil, high; substrata, high. Piping: very high to high hazard. | Resistance to erosion, very high. Establishment of vegetation, difficult. |
| Everett gravelly loam | Stability: low to high. Compacted permeability: pervious to impervious. Shrink-swell potential: low to moderate. Piping hazard through: fill - high to very high. Suitability: good to fair when compacted with crawler tractor or steel-wheeled roller. | Permeability: subsoil, 5.0-10.0 in/hr; substratum, 5.0-10.0 in/hr. Not suitable. | Shearing strength: subsoil, low to very low; substratum, high. Compacted permeability: pervious to impervious. Compressibility: very slight to medium. Stability: subsoil, low; substratum, high to moderate. Piping: high to very high hazard. | Resistance to erosion, moderate. Establishment of vegetation, fairly difficult. |
| Everson silt loam<br>Everson fine sandy loam<br>Everson clay loam | Stability: low to moderate. Compacted permeability: semipervious to impervious. Shrink-swell potential: moderate to low. May crack when dry. Piping hazard through: fill - high to low hazard. | Permeability: subsoil, less than 0.05 in/hr; substrata, 0.2-0.8 in/hr. Suitability: good to poor. May crack when dry. | Shearing strength: subsoil, moderate to low; substrata, moderate. Compacted permeability: semipervious to impervious. Compressibility: medium to high. Stability: subsoil, low; substrata, moderate. Piping: high to low hazard. | Resistance to erosion, low to moderate. Establishment of vegetation, fairly easy. |
| Fidalgo rocky loam | Stability: low. Compacted permeability: semipervious to impervious. Shrink-swell potential: moderate to low. Piping hazard through: fill - low to moderate when compacted with sheeps-foot roller. | Permeability: subsoil, 0.8-2.5 in/hr; substratum, less than 0.05 in/hr. Serpentine bedrock at 1 to more than 2 feet. | Shearing strength: subsoil, low to very low; substratum, low to very low. Compacted permeability: semipervious to impervious. Compressibility: very slight to medium. Stability: subsoil, low; substratum, low. Piping: low to moderate hazard. | Resistance to erosion, moderate. Establishment of vegetation, fairly difficult. |

Table 16. Soil features affecting engineering practices for water impoundments or disposal, Puget Sound Area (con.)

| Soil Series and Type | Dikes or Levees | Farm Ponds: Reservoir Area | Farm Ponds: Embankments | Terraces, Diversions and Waterways |
|---|---|---|---|---|
| Fitch gravelly sandy loam | Stability: high. Compacted permeability: pervious to semipervious. Shrink-swell potential: low. Piping hazard through: fill - very high. Suitability: good when compacted with crawler tractor or steel-wheeled roller. | Permeability: subsoil, 5.0-10.0 in/hr; substratum, 5.0-10.0 in/hr. Not suitable. | Shearing strength: subsoil, very high; substratum, very high to moderate. Compacted permeability: pervious to semipervious. Compressibility: very slight. Stability: subsoil, high; substratum, high. Piping: very high hazard. | Resistance to erosion, very high. Establishment of vegetation, difficult. |
| Fresh water marsh | Not suitable. | Not suitable. | Not suitable. | |
| Giles loam<br>Giles silt loam<br>Giles silt loam, gravelly subsoil<br>Giles/Tromp* silt loams complex<br>(*see Tromp silt loam) | Stability: low to moderate. Compacted permeability: semipervious to impervious. Shrink-swell potential: moderate to low. Piping hazard through: fill - high to low. Suitability: good to poor when compacted with sheeps-foot roller. | Permeability: subsoil, 0.2-0.8 in/hr; substrata, 0.8-2.5 in/hr. Suitability: good to poor. May crack when dry. | Shearing strength: subsoil, very low; substrata, very low. Compacted permeability: semipervious to impervious. Compressibility: medium to high. May crack when dry. Stability: subsoil, low; substrata, low to moderate. Piping: high to low hazard. | Resistance to erosion, low. On tilled slopes above 8%. Establishment of vegetation, easy. |
| Giles fine sandy loam | Stability: low. Compacted permeability: semipervious to impervious. Shrink-swell potential: low. Piping hazard through: fill - high hazard. Suitability: good to poor when compacted with sheeps-foot roller. | Permeability: subsoil, 0.2-0.8 in/hr; substratum, 0.8-2.5 in/hr. Suitability: fair to not suitable. | Shearing strength: subsoil, low; substratum, low. Compacted permeability: semipervious to impervious. Compressibility: very slight to medium. Stability: subsoil, low; substratum, low. Piping: high hazard. | Resistance to erosion, low. On tilled slopes above 8%. Establishment of vegetation, easy. |
| Gilligan loam<br>Gilligan silt loam | Stability: low to moderate. Compacted permeability: very pervious to semipervious. Shrink-swell potential: low to moderate. Piping hazard through: fill - high to very high. Suitability: good to poor when compacted with sheeps-foot roller. | Permeability: subsoil, 0.2-0.8 in/hr; substrata, 0.8-2.5 in/hr. Suitability: poor to not suitable. | Shearing strength: subsoil, very low; substrata, low to high. Compacted permeability: very pervious to semi-pervious. Compressibility: medium to very slight. Stability: subsoil, low; substrata, low to moderate. Piping: high to very high hazard. | Resistance to erosion, moderate. Establishment of vegetation, fairly difficult. |

Table 16. Soil features affecting engineering practices for water impoundments or disposal, Puget Sound Area (con.)

| Soil Series and Type | Dikes or Levees | Farm Ponds | | Terraces, Diversions and Waterways |
|---|---|---|---|---|
| | | Reservoir Area | Embankments | |
| Gilligan gravelly loam | Stability: high to low. Compacted permeability: semipervious to impervious. Shrink-swell potential: low to moderate. Piping hazard through: fill - high. Suitability: good to poor when compacted with sheeps-foot roller. | Permeability: subsoil, 0.2-0.8 in/hr; substratum, 0.8-2.5 in/hr. Suitability: fair to poor. | Shearing strength: subsoil, low; substratum, low. Compacted permeability: semipervious to impervious. Compressibility: very slight to medium. Stability: subsoil, low; substratum, low. Piping: high hazard. | Resistance to erosion, moderate. Establishment of vegetation, fairly difficult. |
| Gravel pits | Stability: high. Compacted permeability: pervious. Shrink-swell potential: low. Piping hazard through: fill - very high. | Permeability: subsoil, over 10.0 in/hr; substrata, over 10.0 in/hr. Not suitable. | Shearing strength: subsoil, very high; substrata, very high. Compacted permeability: pervious. Compressibility: very slight. Stability: subsoil, high; substrata, high. Piping: very high hazard. | Resistance to erosion, very high. Establishment of vegetation, very difficult. |
| Greenwater sand<br>Greenwater loamy sand<br>Greenwater sandy loam | Stability: low to moderate. Compacted permeability: pervious to semipervious. Shrink-swell potential: low. Piping hazard through: fill - high to very high. Suitability: good to poor when compacted with sheeps-foot roller. | Permeability: subsoil, 5.0-10.0 in/hr; substrata, 5.0-10.0 in/hr. Suitability: unsuitable. | Shearing strength: subsoil, very high; substrata, low to very low. Compacted permeability: pervious to semipervious. Compressibility: very slight to medium. Stability: subsoil, high; substrata, low. Piping: high to very high hazard. | Resistance to erosion, moderate. Establishment of vegetation, fairly difficult to difficult. |
| Greenwood peat | Not suitable. Low volume weight. Low stability. Remove from foundation. | Not suitable. Remove from area. | Not suitable. Low volume weight. Low stability. | Resistance to erosion, very low. Establishment of vegetation, very difficult. |
| Grove gravelly loam<br>Grove gravelly sandy loam<br>Grove stony sandy loam<br>Grove cobbly sandy loam<br>Grove gravelly loamy sand | Stability: high to low. Compacted permeability: pervious to semipervious. Shrink-swell potential: low. Piping hazard through: fill - very high to moderate. Suitability: good when compacted with crawler tractor. | Permeability: subsoil, 2.5-5.0 in/hr; substrata, 5.0-10.0 in/hr. Not suitable. | Shearing strength: subsoil, very high; substrata, very high to low. Compacted permeability: pervious to semipervious. Compressibility: very slight to medium. Stability: subsoil, high to low; substrata, high to low. Piping: very high to moderate hazard. | Resistance to erosion, very high. Establishment of vegetation, very difficult. |

Table 16. Soil features affecting engineering practices for water impoundments or disposal, Puget Sound Area (con.)

| Soil Series and Type | Dikes or Levees | Farm Ponds: Reservoir Area | Farm Ponds: Embankments | Terraces, Diversions and Waterways |
|---|---|---|---|---|
| Hale silt loam<br>Hale-Norma* silt loam<br>(*see Norma silt loam) | Stability: low.<br>Compacted permeability: semipervious to impervious.<br>Shrink-swell potential: moderate to low. Piping hazard through: fill - high hazard. Suitability: good to poor when compacted with sheeps-foot roller. | Permeability: subsoil, 2.5-5.0 in/hr; substrata, less than 0.05 in/hr.<br>Suitability: fair to poor. | Shearing strength: subsoil, very low; substrata, low.<br>Compacted permeability: semipervious to impervious.<br>Compressibility: very slight to medium.<br>Stability: subsoil, low; substrata, low.<br>Piping: high hazard. | Resistance to erosion, low.<br>On tilled slopes over 8%.<br>Establishment of vegetation, easy. |
| Harstine gravelly sandy loam | Stability: low.<br>Compacted permeability: semipervious to impervious.<br>Shrink-swell potential: low.<br>Piping hazard through: fill - high. Suitability: good to poor when compacted with sheeps-foot roller. | Permeability: subsoil, 0.8-2.5 in/hr; substratum, 0.05-0.2 in/hr.<br>Cemented glacial till substratum.<br>Suitability: good. | Shearing strength: subsoil, low; substratum, low.<br>Compacted permeability: semipervious to impervious.<br>Compressibility: very slight to medium. Stability: subsoil, low; substratum, low.<br>Piping: high hazard. | Resistance to erosion, low.<br>On tilled slopes over 8%.<br>Establishment of vegetation, fairly difficult. |
| Heisler gravelly loam<br>Heisler shaly loam<br>Heisler stony loam | Stability: low to moderate.<br>Compacted permeability: semipervious to impervious.<br>Shrink-swell potential: low to moderate. Piping hazard through: fill - high to moderately low. Suitability: good to poor when compacted with sheeps-foot roller. | Permeability: subsoil, 0.2-0.8 in/hr; substrata, 0.05-0.2 in/hr.<br>Suitability: fair to very good. | Shearing strength: subsoil, low; substrata, low.<br>Compacted permeability: semipervious to impervious.<br>Compressibility: very slight to medium. Stability: subsoil, low; substrata, low to moderate. Piping: high to moderately low hazard. | Resistance to erosion, low.<br>On tilled slopes over 8%.<br>Establishment of vegetation, fairly difficult. |
| Hemmi silt loam | Stability: moderate.<br>Compacted permeability: pervious to impervious.<br>Shrink-swell potential: high to low.<br>Piping hazard through: fill - low to very high hazard.<br>Suitability: good to very poor when compacted with sheeps-foot roller. May crack when dry. | Permeability: subsoil, less than 0.05 in/hr; substratum, 2.5-5.0 in/hr.<br>Suitability: not suitable because of substratum permeability. | Shearing strength: subsoil, low to very low; substratum, high.<br>Compacted permeability: pervious to impervious.<br>Compressibility: subsoil, very high; substratum, very slight.<br>Stability: subsoil, moderate; substratum, moderate. | Resistance to erosion, moderate.<br>Establishment of vegetation, difficult. |

Table 16. Soil features affecting engineering practices for water impoundments or disposal, Puget Sound Area (con.)

| Soil Series and Type | Dikes or Levees | Farm Ponds | | Terraces, Diversions and Waterways |
|---|---|---|---|---|
| | | Reservoir Area | Embankments | |
| Hoodsport gravelly sandy loam<br>Hoodsport stony sandy loam<br>Hoodsport very gravelly sandy loam | Stability: high to low.<br>Compacted permeability: impervious to pervious.<br>Shrink-swell potential: low.<br>Piping hazard through: fill - high to very high.<br>Suitability: good to poor.<br>Cemented very gravelly sands at 2 to 3 feet. | Permeability: subsoil, 2.5-5.0 in/hr; substrata, less than 0.05 in/hr.<br>Suitability: fairly well suited. | Shearing strength: subsoil, low to high; substrata, low to high.<br>Compacted permeability: impervious to pervious.<br>Compressibility: very slight to medium.<br>Stability: subsoil, high to low; substrata, high to low.<br>Piping: high to very high hazard. | Resistance to erosion, moderate.<br>On tilled slopes over 8%.<br>Establishment of vegetation, fairly difficult. |
| Hovde gravelly sandy loam<br>Hovde loamy sand<br>Hovde silty clay loam<br>Hovde sand<br>Hovde loam | Stability: low to high.<br>Compacted permeability: pervious to very pervious.<br>Shrink-swell potential: low.<br>Piping hazard through: foundation - high to very high.<br>Suitability: good to poor when compacted with sheepsfoot roller or steel-wheeled roller. | Permeability: subsoil, 0.2-0.8 in/hr; substrata, 5.0-10.0 in/hr.<br>Suitability: not suitable.<br>High water table. | Shearing strength: subsoil, low to high; substrata, low to high.<br>Compacted permeability: pervious to very pervious.<br>Compressibility: very slight to medium.<br>Stability: subsoil, low to high; substrata, low to high.<br>Piping: high to very high hazard. | Resistance to erosion, low.<br>Establishment of vegetation, difficult. |
| Hoypus coarse sandy loam<br>Hoypus gravelly loamy sand | Stability: low to high.<br>Compacted permeability: pervious to impervious.<br>Shrink-swell potential: low.<br>Piping hazard through: fill - high to very high.<br>Not suitable. | Permeability: subsoil, 5.0-10.0 in/hr; substrata, 5.0-10.0 in/hr.<br>Not suitable. | Shearing strength: subsoil, very high to low; substrata, very high to high.<br>Compacted permeability: pervious to impervious.<br>Compressibility: very slight.<br>Stability: subsoil, high to low; substrata, high to moderate.<br>Piping: high to very high hazard.<br>Not suitable. | Resistance to erosion, very high.<br>On cleared slopes over 15%.<br>Establishment of vegetation, very difficult. |

Table 16. Soil features affecting engineering practices for water impoundments or disposal, Puget Sound Area. (con.)

| Soil Series and Type | Dikes or Levees | Farm Ponds | | Terraces, Diversions and Waterways |
|---|---|---|---|---|
| | | Reservoir Area | Embankments | |
| Indianola fine sandy loam<br>Indianola sandy loam<br>Indianola loamy fine sand<br>Indianola loam<br>Indianola sandy loam/ Roche* loam complex (*see Roche loam)<br>Indianola loamy sand | Stability: low to moderate.<br>Compacted permeability: pervious to semipervious.<br>Shrink-swell potential: low.<br>Piping hazard through: fill - very high to high.<br>Suitability: good when compacted with sheeps-foot roller. | Permeability: subsoil, 2.5-5.0 in/hr; substrata, 5.0-10.0 in/hr.<br>Suitability: not suitable because of rapid permeability. | Shearing strength: subsoil, high to very high; substrata, high to very high.<br>Compacted permeability: pervious to semipervious.<br>Compressibility: very slight to medium.<br>Stability: subsoil, low to moderate; substrata, low to moderate.<br>Piping: very high to high hazard. | *Indianola fine sandy loam*, Indianola sandy loam, and Indianola sandy loam (Roche complex): Resistance to erosion, low; on tilled slopes above 8%; establishment of vegetation, fairly difficult to difficult.<br>Indianola loam: Resistance to erosion, low; establishment of vegetation, easy to fairly difficult; on tilled slopes over 15%.<br>Indianola loamy sand and Indianola loamy fine sand: Resistance to erosion, low; establishment of vegetation, difficult. |
| Indianola silt loam | Stability: low.<br>Compacted permeability: semipervious to impervious.<br>Shrink-swell potential: moderate to low.<br>Piping hazard through: fill - high.<br>Suitability: good to poor when compacted with sheeps-foot roller. | Permeability: subsoil, 2.5-5.0 in/hr; substratum, 5.0-10.0 in/hr.<br>Suitability: not suitable because of rapid permeability. | Shearing strength: subsoil, low to very low; substratum, low.<br>Compacted permeability: semipervious to impervious.<br>Compressibility: very slight, to medium.<br>Stability: subsoil, low; substratum, low.<br>Piping: high hazard. | Resistance to erosion, low. On tilled slopes over 15%. Establishment of vegetation, easy to fairly difficult. |
| Issaquah silt loam | Stability: low.<br>Compacted permeability: semipervious to impervious.<br>Shrink-swell potential: moderate to high. May crack when dry.<br>Piping hazard through: foundation - high to low; fill - high to low.<br>Suitability: very poor to good when compacted with sheeps-foot roller. | Permeability: subsoil, 0.05-0.2 in/hr; substratum, less than 0.05 in/hr. | Shearing strength: subsoil, very low; substratum, very low.<br>Compacted permeability: semipervious to impervious.<br>May crack when dry.<br>Compressibility: medium to very high.<br>Stability: subsoil, low; substratum, low.<br>Piping: high to low hazard. | Resistance to erosion, low. Establishment of vegetation, fairly easy. |

Table 16. Soil features affecting engineering practices for water impoundments or disposal, Puget Sound Area (con.)

| Soil Series and Type | Dikes or Levees | Farm Ponds | | Terraces, Diversions and Waterways |
|---|---|---|---|---|
| | | Reservoir Area | Embankments | |
| Juno gravelly sandy loam<br>Juno loamy sand<br>Juno sandy loam<br>Juno loam | Stability: low to moderate.<br>Compacted permeability: pervious to semipervious.<br>Shrink-swell potential: low.<br>Piping hazard through: foundation - high to very high; fill - high to very high. Suitability: sandy loams good when compacted with sheeps-foot roller. Loamy sand good when compacted with crawler tractor. | Permeability: subsoil, 5.0-10.0 in/hr; substrata, over 10.0 in/hr.<br>Suitability: not suitable. | Shearing strength: subsoil, high to low; substrata, high to low.<br>Compacted permeability: pervious to semipervious.<br>Compressibility: very slight.<br>Stability: subsoil, low; substrata, low.<br>Piping: very high to high hazard. | Resistance to erosion, low to moderate.<br>Establishment of vegetation, fairly difficult.<br>Exception: Juno loamy sand, resistance to erosion, moderate; establishment of vegetation, difficult. |
| Kapowsin gravelly clay loam<br>Kapowsin gravelly sandy loam<br>Kapowsin gravelly loam | Stability: low to moderate.<br>Compacted permeability: semipervious to impervious.<br>Shrink-swell potential: low to moderate.<br>Piping hazard through: fill - high to moderately low.<br>Suitability: good to poor when compacted with sheeps-foot roller. | Permeability: subsoil, 0.2-0.8 in/hr; substrata, 0.05-0.2 in/hr.<br>Suitability: very good to fair. | Shearing strength: subsoil, low; substrata, low.<br>Compacted permeability: semipervious to impervious.<br>Compressibility: very slight to *medium*.<br>Stability: subsoil, low to moderate; substrata, low.<br>Piping: high to moderately low hazard. | Kapowsin gravelly clay loam: Resistance to erosion, moderate; over 3% slopes; establishment of vegetation, fairly difficult.<br>Kapowsin gravelly sandy loam: *Resistance to erosion*, *moderate* to low; slopes over 8%; establishment of vegetation, fairly difficult.<br>Kapowsin gravelly loam: Resistance to erosion, low to moderate; over 3% slopes; establishment of vegetation, difficult. |
| Keystone fine sandy loam<br>Keystone loamy sand | Stability: low to moderate.<br>Compacted permeability: pervious to semipervious.<br>Shrink-swell potential: low.<br>Piping hazard through: fill - very high.<br>Suitability: good when compacted with crawler tractor. | Permeability: subsoil, 5.0-10.0 in/hr; substrata, 5.0-10.0 in/hr.<br>Not suitable. | Shearing strength: subsoil, low; substrata, high to low.<br>Compacted permeability: pervious to semipervious.<br>Compressibility: very slight.<br>Stability: subsoil, low; substrata, moderate to low.<br>Piping: very high hazard. | Resistance to erosion, moderate.<br>Establishment of vegetation, difficult. |
| Kickerville silt loam | Stability: high.<br>Compacted permeability: very pervious to semipervious.<br>Shrink-swell potential: low.<br>Piping hazard through: fill - very high to high.<br>Suitability: good when compacted. | Permeability: subsoil, 2.5-5.0 in/hr; substratum, 5.0-10.0 in/hr. (to less than 0.05 in/hr. at 10 ft.)<br>Not suitable. | Shearing strength: subsoil, moderate; substratum, high.<br>Compacted permeability: very pervious to semipervious.<br>Compressibility: very slight.<br>Stability: subsoil, high. substratum, high. Piping: very high to high hazard. | Resistance to erosion, moderate to high.<br>On tilled slopes over 15%.<br>Establishment of vegetation, fairly difficult. |

Table 16. Soil features affecting engineering practices for water impoundments or disposal, Puget Sound Area (con.)

| Soil Series and Type | Dikes or Levees | Farm Ponds | | Terraces, Diversions and Waterways |
|---|---|---|---|---|
| | | Reservoir Area | Embankments | |
| Kitsap silt loam<br>Kitsap loam<br>Kitsap silty clay loam<br>Kitsap gravelly loam<br>Kitsap loam/Indianola* fine sandy loam complex (*see Indianola fine sandy loam) | Stability: low to moderate.<br>Compacted permeability: semipervious to impervious.<br>Shrink-swell potential: moderate to high.<br>Cracks when dry.<br>Piping hazard through: fill - low to high.<br>Suitability: good to poor when compacted with sheepsfoot roller. | Permeability: subsoil, 0.05-0.2 in/hr; substrata, less than 0.05 in/hr.<br>Suitability: very poor to good. | Shearing strength: subsoil, very low; substrata, very low.<br>Compacted permeability: semipervious to impervious.<br>Compressibility: medium to very high.<br>Stability: subsoil, low to moderate; substrata, low to moderate.<br>Piping: high hazard because of laminated structure. | Resistance to erosion, moderate to high.<br>On slopes over 3%.<br>Landslide hazard.<br>Establishment of vegetation, fairly easy to fairly difficult. |
| Klaber silty clay loam | Stability: moderate.<br>Compacted permeability: impervious.<br>Shrink-swell potential: high.<br>Cracks when dry. | Permeability: subsoil, 0.05-0.2 in/hr; substrata, less than 0.05 in/hr.<br>Suitability: good. | Shearing strength: very low.<br>Compacted permeability: impervious.<br>Compressibility: very high.<br>Stability: moderate.<br>Cracks when dry. | Resistance to erosion, high.<br>Establishment of vegetation, fairly difficult. |
| Klaus gravelly loam<br>Klaus gravelly sandy loam<br>Klaus sandy loam | Stability: high.<br>Compacted permeability: semipervious to pervious.<br>Shrink-swell potential: low.<br>Piping hazard through: fill - high to very high.<br>Suitability: good when compacted with sheeps-foot roller. | Permeability: subsoil, 2.5-5.0 in/hr; substrata, 5.0-10.0 in/hr.<br>Not suitable. | Shearing strength: subsoil, moderate; substrata, moderate to very high.<br>Compacted permeability: semipervious to pervious.<br>Compressibility: very slight.<br>Stability: subsoil, high; substrata, high.<br>Piping: high to very high hazard. | Resistance to erosion, moderate.<br>On tilled slopes over 8%.<br>Establishment of vegetation, fairly difficult to difficult. |
| Kline gravelly loam<br>Kline gravelly silt loam<br>Kline loam<br>Kline silt loam<br>Kline sandy loam | Stability: high.<br>Compacted permeability: semipervious to very pervious.<br>Shrink-swell potential: low.<br>Piping hazard through: foundation - very high; fill - high to very high.<br>Suitability: good when compacted with crawler or steel-wheeled tractor. | Permeability: subsoil, 0.8-2.5 in/hr; substrata, 2.5-5.0 in/hr.<br>Not suitable. | Shearing strength: subsoil, very high to moderate; substrata, high.<br>Compacted permeability: semipervious to very pervious.<br>Compressibility: very slight.<br>Stability: subsoil, high; substrata, high.<br>Piping: high to very high hazard. | Resistance to erosion, moderate.<br>Establishment of vegetation, fairly difficult.<br>Exception: Kline sandy loam, resistance to erosion, moderate to very high; establishment of vegetation, difficult. |

Table 16. Soil features affecting engineering practices for water impoundments or disposal, Puget Sound Area (con.)

| Soil Series and Type | Dikes or Levees | Farm Ponds | | Terraces, Diversions and Waterways |
|---|---|---|---|---|
| | | Reservoir Area | Embankments | |
| Koch gravelly loam<br>Koch gravelly sandy loam<br>Koch silt loam | Stability: low to moderate. Compacted permeability: semipervious to pervious. Shrink-swell potential: low. Piping hazard through: foundation - high to very high; fill - high to very high. Suitability: good to poor when compacted. | Permeability: subsoil, 0.2-0.8 in/hr; substrata, 0.05-0.2 in/hr. Not suitable to fair. | Shearing strength: subsoil, low; substrata, high to low. Compacted permeability: semipervious to pervious. Compressibility: very slight, to medium. Stability: subsoil, low; substrata, low to moderate. Piping: high to very high hazard. | Resistance to erosion, low. Establishment of vegetation, difficult. |
| Kopiah loam<br>Kopiah silt loam<br>Kopiah silty clay loam | Stability: moderate to low. Compacted permeability: impervious to semipervious. Shrink-swell potential: high to moderate. Cracks when dry. Piping hazard through: fill - low to moderately low. *Suitability: good to poor* when compacted with sheeps-foot roller. | Permeability: subsoil, 0.2-0.8 in/hr; substrata, less than 0.05 in/hr. Well suited. | Shearing strength: subsoil, low to very low; substrata, very low to low. Compacted permeability: impervious to semipervious. Compressibility: very high to medium. Stability: subsoil, moderate to low; substrata, moderate to low. Piping: low to moderately low hazard. | Resistance to erosion, moderate. Establishment of vegetation, fairly difficult. |
| Labounty silt loam<br>Labounty silt loam/ McKenna silty clay loam complex (see McKenna silty clay loam) | Stability: moderate. Compacted permeability: impervious. Cracks when dry. Shrink-swell potential: moderate to high. Cracks when dry. Piping hazard through: fill - low. Suitability: good to poor when compacted with sheeps-foot roller. | Permeability: subsoil, 0.5-0.2 in/hr; substrata, less than 0.05 in/hr. Suitability: well suited. Cracks when dry. | Shearing strength: subsoil, very low; substrata, very low. Compacted permeability: impervious. Cracks when dry. Compressibility: medium to very high. Stability: subsoil, moderate; substrata, moderate. Piping: low hazard. | Resistance to erosion, moderate. On slopes over 3%. Establishment of vegetation, fairly easy. |
| Lummi silty clay loam<br>Lummi silt loam | Stability: low. Compacted permeability: semipervious to impervious. Shrink-swell potential: high to moderate. Cracks when dry. Piping hazard through: foundation - low; fill - low. Suitability: good to very poor when compacted with sheeps-foot roller. | Permeability: subsoil, 0.05-0.2 in/hr; substrata, 0.05-0.2 in/hr. Suitability: good. | Shearing strength: subsoil, very low; substrata, very low. Compacted permeability: semipervious to impervious. Cracks when dry. Compressibility: very high to medium. Stability: subsoil, low; substrata, low. Piping: low hazard. | Resistance to erosion, low. Establishment of vegetation, fairly easy. |

Table 16. Soil features affecting engineering practices for water impoundments or disposal, Puget Sound Area (con.)

| Soil Series and Type | Dikes or Levees | Farm Ponds | | Terraces, Diversions and Waterways |
|---|---|---|---|---|
| | | Reservoir Area | Embankments | |
| Lummi fine sandy loam | Stability: moderate. Compacted permeability: pervious. Shrink-swell potential: very low. Piping hazard through: foundation - very high; fill - very high. Suitability: good when compacted with crawler tractor. | Permeability: subsoil, 0.05-0.2 in/hr; substratum, 0.05-0.2 in/hr. Suitability: very poor. | Shearing strength: subsoil, very high; substratum, very high. Compacted permeability: pervious. Compressibility: very slight. Stability: subsoil, moderate; substratum, moderate. Piping: very high hazard. | Resistance to erosion, low. Establishment of vegetation, fairly easy. |
| Lynden loamy sand<br>Lynden sandy loam<br>Lynden gravelly sandy loam | Stability: moderate. Compacted permeability: pervious. Shrink-swell potential: low. Piping hazard through: fill - very high. Suitability: good when compacted with crawler tractor. | Permeability: subsoil, 2.5-5.0 in/hr; substrata, 5.0-10.0 in/hr. Not suitable. | Shearing strength: subsoil, high; substrata, high. Compacted permeability: pervious. Compressibility: very slight. Stability: subsoil, moderate. substrata, moderate. Piping: very high hazard. | Lynden loamy sand: Resistance to erosion, low. Establishment of vegetation, difficult. Lynden sandy loam and Lynden gravelly sandy loam: Resistance to erosion, low. On slopes over 8%. Establishment of vegetation, difficult. |
| Lynden loam<br>Lynden gravelly loam | Stability: low to moderate. Compacted permeability: semipervious to pervious. Shrink-swell potential: low. Piping hazard through: fill - high to very high. Suitability: good when compacted. | Permeability: subsoil, 2.5-5.0 in/hr; substrata, 5.0-10.0 in/hr. Not suitable. | Shearing strength: subsoil, low; substrata, very high. Compacted permeability: semipervious to pervious. Compressibility: very slight. Stability: subsoil, low; substrata, moderate. Piping: high to very high. | Resistance to erosion, low. On slopes over 8%. Establishment of vegetation, easy. |
| Lystair sandy loam<br>Lystair fine sandy loam<br>Lystair loamy sand | Stability: low. Compacted permeability: semipervious. Shrink-swell potential: low. Piping hazard through: fill - high. Suitability: poor to good when compacted with sheeps-foot roller. | Permeability: subsoil, 5.0-10.0 in/hr; substrata, 5.0-10.0 in/hr. Not suitable. | Shearing strength: subsoil, low; substrata, low. Compacted permeability: semipervious. Compressibility: very slight. Stability: subsoil, low. substrata, low. Piping: high hazard. | Resistance to erosion, low. Establishment of vegetation, fairly easy. |

Table 16. Soil features affecting engineering practices for water *impoundments* or disposal, Puget Sound Area (con.)

| Soil Series and Type | Dikes or Levees | Farm Ponds | | Terraces, Diversions and Waterways |
|---|---|---|---|---|
| | | Reservoir Area | Embankments | |
| Marblemount stony loam | Stability: high. Compacted permeability: very pervious to semipervious. Shrink-swell potential: low. Piping hazard through: fill - high to very high. Granite bedrock at 1 to 6 feet. | Permeability: subsoil, 0.8-2.5 in/hr; substratum, less than 0.05 in/hr. Not suitable. | Shearing strength: subsoil, moderate; substratum, high. Compacted permeability: very pervious to semipervious. Compressibility: very slight. Stability: subsoil, high; substratum, high. Piping: high to very high hazard. | Where cleared. Resistance to erosion, moderate. Establishment of vegetation, very difficult. |
| Maytown silt loam<br>Maytown fine sandy loam | Stability: low to moderate. Compacted permeability: semipervious to impervious. Shrink-swell potential: moderate to low. May crack when dry. Piping hazard through: foundation - high to low; fill - high to low. Suitability: good to poor when compacted with sheepsfoot roller. | Permeability: subsoil, 0.8-2.5 in/hr; substrata, 0.05-0.2 in/hr. Suitability: fair to poor. | Shearing strength: subsoil, very low; substrata, low. Compacted permeability: semipervious to impervious. Compressibility: medium to high. Stability: subsoil, low to moderate; substrata, low. Piping: high to low hazard. | Resistance to erosion, low. Establishment of vegetation, fairly easy. |
| McKenna gravelly clay loam<br>McKenna gravelly loam | Stability: low to high. Compacted permeability: semipervious to impervious. Shrink-swell potential: low. Piping hazard through: fill - high. Cemented glacial till at $1\frac{1}{2}$ to 2 feet. | Permeability: subsoil, 0.2-0.8 in/hr; substrata, less than 0.05 in/hr. Well suited. | Shearing strength: subsoil, low, substrata, high to moderate. Compacted permeability: semipervious to impervious. Compressibility: very slight. Stability: subsoil, low; substrata, high. Piping: high hazard. | Resistance to erosion, low. Establishment of vegetation, difficult. |
| McKenna silty clay loam<br>McKenna loam | Stability: low. Compacted permeability: semipervious to impervious. Shrink-swell potential: high. Cracks when dry. Piping hazard through: fill - variable; low to high. Suitability: poor to very poor. | Permeability: subsoil, 0.2-0.8 in/hr; substrata, less than 0.05 in/hr. Suitability: good. Cracks when dry. | Shearing strength: subsoil, very low; substrata, very low. Compacted permeability: semipervious to impervious. Cracks when dry. Compressibility: very high. Stability: subsoil, low; substrata, low. Piping: variable; low to high hazard. | Resistance to erosion, low. Establishment of vegetation, difficult. |

Table 16. Soil features affecting engineering practices for water impoundments or disposal, Puget Sound Area (con.)

| Soil Series and Type | Dikes or Levees | Farm Ponds: Reservoir Area | Farm Ponds: Embankments | Terraces, Diversions and Waterways |
|---|---|---|---|---|
| McMurray (Rifle) peat<br>McMurray (Carbondale) muck<br>Mukilteo peat<br>Semiahmoo muck<br>McMurray peat, shallow over Mukilteo peat<br>Rifle (McMurray) peat/ Bellingham* silty clay loam complex (*see Bellingham silty clay loam) | Not suitable. Low volume weight. Low strength. Settles. Remove from foundation. | Remove. | Not suitable. Low volume weight. Low strength. | Resistance to erosion, low. Establishment of vegetation, easy. |
| McMurray (Rifle) peat, shallow<br>McMurray (Carbondale) muck, shallow<br>Mukilteo peat, shallow<br>Semiahmoo muck, shallow | Not suitable. Low volume weight. Low strength. Settles. Remove. | Permeability: subsoil, Variable, 0.2-5.0 in/hr; substrata, 0.05-0.2 in/hr. Remove peat or muck. | Not suitable. Low volume weight. Low strength. | Resistance to erosion, low. Establishment of vegetation, easy. |
| Melbourne loam<br>Melbourne sandy clay loam<br>Melbourne silty clay loam<br>Melbourne stony loam | Stability: moderate to high. Compacted permeability: impervious. Cracks when dry. Shrink-swell potential: moderate to high. Cracks when dry. Piping hazard through: fill - low. Suitability: poor to very poor. | Permeability: subsoil, 0.2-0.8 in/hr; substrata, 0.05-0.2 in/hr. Suitability: good. Cracks when dry. | Shearing strength: subsoil, very low; substrata, very low. Compacted permeability: impervious. Cracks when dry. Compressibility: medium to very high. Stability: subsoil, moderate; substrata, high. Piping: low hazard. | Resistance to erosion, moderate. On tilled areas over 3% slope. Establishment of vegetation, fairly easy. |
| National pumicy loam<br>National pumicy sandy loam | Stability: low. Compacted permeability: semipervious. Shrink-swell potential: low. Piping hazard through: fill - high. Poorly suited. | Permeability: subsoil, 5.0-10.0 in/hr; substrata, 0.2-0.8 in/hr. Not suitable. | Shearing strength: subsoil, low; substrata, low. Compacted permeability: semipervious. Compressibility: very slight. Stability: subsoil, low; substrata, low. Piping: high hazard. | Resistance to erosion, moderate. Establishment of vegetation, easy. |
| Neptune sandy loam<br>Neptune gravelly sandy loam | Stability: high. Compacted permeability: very pervious to pervious. Shrink-swell potential: low. Piping hazard through: foundation - very high; fill-very high. | Permeability: subsoil, 2.5-5.0 in/hr; substrata, 5.0-10.0 in/hr. Not suitable. | Shearing strength: subsoil, very high; substrata, high. Compacted permeability: very pervious to pervious. Compressibility: very slight. Stability: subsoil, high; substrata, high. Piping: very high. | Resistance to erosion, high. Establishment of vegetation, difficult. |

Table 16. Soil features affecting engineering practices for water impoundments or disposal, Puget Sound Area (con.)

| Soil Series and Type | Dikes or Levees | Farm Ponds | | Terraces, Diversions and Waterways |
|---|---|---|---|---|
| | | Reservoir Area | Embankments | |
| **Nesika loam**<br>**Nesika soils, undifferentiated** | Stability: low to high. Compacted permeability: semipervious to very pervious. Shrink-swell potential: low. Piping hazard through: fill - high to very high. Suitability: good to poor when compacted. | Permeability: subsoil, 0.8-2.5 in/hr; substrata, 2.5-5.0 in/hr. Not suitable. | Shearing strength: subsoil, low to high; substrata, low to high. Compacted permeability: semipervious to very pervious. Compressibility: very slight. Stability: subsoil, low to high; substrata, low to high. Piping: high to very high. | Resistance to erosion, low to moderate. Establishment of vegetation, fairly difficult. |
| **Newberg loam**<br>**Newberg silt loam** | Stability: low to moderate. Compacted permeability: semipervious to impervious. Shrink-swell potential: low to high. Piping hazard through: foundation - high; fill - high. Suitability: good to poor when compacted with sheeps-foot roller. | Permeability: subsoil, 2.5-5.0 in/hr; substrata, 5.0-10.0 in/hr. Suitability: not suitable. Rapid permeability. | Shearing strength: subsoil, very low; substrata, low. Compacted permeability: semipervious to impervious. Compressibility: very slight to very high. Stability: subsoil, low to moderate; substrata, low. Piping: high hazard. | Resistance to erosion, low to moderate. Establishment of vegetation, fairly easy. |
| **Newberg loamy sand**<br>**Newberg loamy fine sand**<br>**Newberg sandy loam**<br>**Newberg fine sandy loam** | Stability: low. Compacted permeability: semipervious to impervious. Shrink-swell potential: moderate to low. Piping hazard through: foundation - high; fill - high. Suitability: good to poor when compacted with sheeps-foot roller. | Permeability: subsoil, 2.5-5.0 in/hr; substrata, 5.0-10.0 in/hr. Suitability: not suitable. Rapid permeability. | Shearing strength: subsoil, low, substrata, low. Compacted permeability: semipervious to impervious. Compressibility: very slight to medium. Stability: subsoil, low; substrata, low. Piping: high hazard. | Resistance to erosion, low to moderate. Establishment of vegetation, fairly easy. |
| Nisqually sand<br>Nisqually loamy sand | Stability: moderate to low. Compacted permeability: pervious to impervious. Shrink-swell potential: low. Piping hazard through: fill - very high to high. | Permeability: subsoil, 2.5-5.0 in/hr; substrata, 5.0-10.0 in/hr. Suitability: not suitable. Rapid permeability. | Shearing strength: subsoil, low; substrata, low to high. Compacted permeability: pervious to impervious. Compressibility: very slight to medium. Stability: subsoil, low; substrata, moderate to low. Piping: very high hazard. | Resistance to erosion, low. Establishment of vegetation, fairly difficult to difficult. |

Table 16. Soil features affecting engineering practices for water impoundments or disposal, Puget Sound Area (con.)

| Soil Series and Type | Dikes or Levees | Farm Ponds | | Terraces, Diversions and Waterways |
|---|---|---|---|---|
| | | Reservoir Area | Embankments | |
| Nookachamps silty clay loam<br>Nookachamps silt loam | Stability: low to moderate. Compacted permeability: semipervious to impervious. Shrink-swell potential: moderate to high. Cracks when dry. Piping hazard through: foundation - low; fill - high to low. Suitability: good to very poor when compacted with sheeps-foot roller. | Permeability: subsoil, 0.2-0.8 in/hr; substratum, less than 0.05 in/hr. Suitability: good. Cracks when dry. | Shearing strength: subsoil, very low; substratum, very low. Compacted permeability: semipervious to impervious. Compressibility: medium to very high. Cracks when dry. Stability: subsoil, low; substratum, low to moderate. Piping: high to low hazard. | Resistance to erosion, low. Establishment of vegetation, easy. |
| Nooksack silt loam<br>Nooksack fine sandy loam | Stability: low. Compacted permeability: semipervious to impervious. Shrink-swell potential: moderate to high. May crack when dry. Piping hazard through: foundation - variable; low to high; fill - variable; low to high. Suitability: good to very poor when compacted with sheeps-foot roller. | Permeability: subsoil, 0.2-0.8 in/hr; substrata, 0.05-0.2 in/hr. Suitability: good. May crack when dry and after periodic flooding. | Shearing strength: subsoil, very low; substrata, very low. Compacted permeability: semipervious to impervious. Compressibility: medium to very high. Stability: subsoil, low; substrata, low. Piping: high hazard. | Resistance to erosion, low. Establishment of vegetation, easy. |
| Nordby loam | Stability: low to high. Compacted permeability: semipervious to impervious. Shrink-swell potential: low to moderate. Piping hazard through: fill - high to low. Suitability: good to poor when compacted with sheeps-foot roller. | Permeability: subsoil, 0.8-2.5 in/hr; substratum, 5.0-10.0 in/hr. Not suitable. | Shearing strength: subsoil, moderate to low; substratum moderate. Compacted permeability: semipervious to impervious. Compressibility: very slight to medium. Stability: subsoil, low to moderate; substratum, high. Piping: high. | Resistance to erosion, low to moderate. Establishment of vegetation, fairly difficult. |
| Norma loam<br>Norma fine sandy loam<br>Norma clay loam<br>Norma silty clay loam | Stability: low to high. Compacted permeability: semipervious to impervious. Shrink-swell potential: low to high. Piping hazard through: foundation - high; fill -high. Suitability: good to poor. | Permeability: subsoil, 0.05-2.5 in/hr; substrata, 0.05-2.5 in/hr. Suitability: fair to good. | Shearing strength: subsoil, moderate to very low; substrata, low to very low. Compacted permeability: semipervious to impervious. Compressibility: very slight to very high. Stability: subsoil, low to high; substrata, low. Piping: high hazard. | Resistance to erosion, low to moderate. Establishment of vegetation, fairly difficult. |

Table 16. Soil features affecting engineering practices for water impoundments or disposal, Puget Sound Area (con.)

| Soil Series and Type | Dikes or Levees | Farm Ponds: Reservoir Area | Farm Ponds: Embankments | Terraces, Diversions and Waterways |
|---|---|---|---|---|
| Norma silt loam<br>Norma sandy loam<br>Norma silty clay<br>Norma/Cagey* complex<br>Norma/Hale* complex<br>*see Cagey and Hale soils | Stability: low to moderate. Compacted permeability: semipervious to impervious. Shrink-swell potential: moderate to low. Piping hazard through: foundation - high to low; fill - high to low. Suitability: good to poor. | Permeability: subsoil, 0.05-0.2 in/hr; substrata, 0.05-2.5 in/hr. Suitability: good to poor. | Shearing strength: subsoil very low; substrata, low to very low. Compacted permeability: semipervious to impervious. Compressibility: medium to high. May crack when dry. Stability: subsoil, low to moderate; substrata, low to moderate. Piping: high to low. | Resistance to erosion, low to moderate. Establishment of vegetation, fairly difficult. |
| Nuby silt loam | Stability: low. Compacted permeability: semipervious to impervious. Shrink-swell potential: moderate to low. Piping hazard through: fill - high. Suitability: good to poor when compacted with sheeps-foot roller. | Permeability: subsoil, 0.2-0.8 in/hr; substratum, 2.5-5.0 in/hr. Suitability: fair to poor. | Shearing strength: subsoil, very low; substratum, low. Compacted permeability: semipervious to impervious. Compressibility: very slight to medium. Stability: subsoil, low; substratum, low. Piping: high hazard. | Resistance to erosion, low. Establishment of vegetation, fairly easy. |
| Olete very gravelly silt loam<br>Olete complex | Stability: high. Compacted permeability: semipervious to impervious. Shrink-swell potential: low. Piping hazard through: fill - high to moderately low. Suitability: good to fair. Basalt bedrock at 1 to 3 feet. | Permeability: subsoil, 0.8-2.5 in/hr; substrata, less than 0.05 in/hr. Suitability: basalt bedrock at 1 to 3 feet. | Shearing strength: subsoil, moderate; substrata, moderate. Compacted permeability: semipervious to impervious. Compressibility: slight to very slight. Stability: subsoil, high; substrata, high. Piping: high to moderately low hazard. | Resistance to erosion, moderate. Establishment of vegetation, difficult. |
| Olympic silty clay loam<br>Olympic stony clay loam | Stability: low to moderate. Compacted permeability: semipervious to impervious. Shrink-swell potential: moderate to low. Cracks when dry. Piping hazard through: fill - low. Suitability: good to fair when compacted with sheeps-foot roller. | Permeability: subsoil, 0.2-0.8 in/hr; substrata, 0.2-0.8 in/hr. Good site. | Shearing strength: subsoil, very low; substrata, very low. Compacted permeability: semipervious to impervious. Compressibility: medium to high. May crack when dry. Stability: subsoil, low; substrata, moderate. Piping: low. | Resistance to erosion, low to moderate. Establishment of vegetation, fairly easy. |
| Orcas (Greenwood) peat | Stability: unstable. Shrinks. Not suitable. Low volume weight. Low strength. Shrinks when dry. | Remove. | Not suitable. Low volume weight. Low strength. Shrinks when dry. | Resistance to erosion, low. Establishment of vegetation, fairly easy. |

Table 16. Soil features affecting engineering practices for water impoundments or disposal, Puget Sound Area (con.)

| Soil Series and Type | Dikes or Levees | Farm Ponds | | Terraces, Diversions and Waterways |
|---|---|---|---|---|
| | | Reservoir Area | Embankments | |
| Orcas peat, shallow over gravel | Stability: high. Compacted permeability: impervious. Shrink-swell potential: low. Piping hazard through: foundation, fill - moderately low. Remove peat. | Permeability: subsoil, 0.05-0.2 in/hr; substratum, less than 0.05 in/hr. Remove peat. Excellent. | Shearing strength: subsoil, not suitable. Peat. Substratum, moderate. Compacted permeability: impervious. Compressibility: slight. Stability: subsoil, not suitable; substratum, high. | Resistance to erosion, low. Establishment of vegetation, fairly easy. |
| Orting gravelly sandy loam<br>Orting loam<br>Orting sandy loam<br>Orting stony sandy loam | Stability: low. Compacted permeability: semipervious to impervious. Shrink-swell potential: low. Piping hazard through: fill - high. Suitability: good to poor when compacted with sheeps-foot roller. | Permeability: subsoil, 0.05-0.2 in/hr; substrata, 0.05-0.2 in/hr. Suitability: fairly well suited. | Shearing strength: subsoil, low; substrata, low. Compacted permeability: semipervious to impervious. Compressibility: slight to medium. Stability: subsoil, high; substrata, high. Piping: high hazard. | Resistance to erosion, moderate. Establishment of vegetation, fairly easy. Exception: Orting loam, establishment of vegetation, fairly difficult. |
| Oso loam | Stability: low to high. Compacted permeability: semipervious to impervious. Shrink-swell potential: low to moderate. Piping hazard through: fill - high. Suitability: good to poor when compacted with sheeps-foot roller. | Permeability: subsoil, 0.2-0.8 in/hr; substratum, 0.05-0.2 in/hr. Suitability: good to poor. | Shearing strength: subsoil, very low; substratum, low to moderate. Compacted permeability: semipervious to impervious. Compressibility: very slight. Stability: subsoil, low; substratum, low to high. Piping: high hazard. | Resistance to erosion, low to moderate. On tilled slopes over 8%. Establishment of vegetation, fairly difficult. |
| Pickett/Rock outcrop complex | Stability: low to moderate. Compacted permeability: semipervious to impervious. Shrink-swell potential: moderate to low. Piping hazard through: fill - high to low. | Permeability: subsoil, 0.8-2.5 in/hr; substratum, less than 0.05 in/hr. Suitability: poor to good. Arkose sandstone at 1 to 3 feet. | Shearing strength: subsoil, very low; substratum, low. Compacted permeability: semipervious to impervious. Compressibility: very slight to medium. Stability: subsoil, low to moderate; substratum, moderate. Piping: high. | On cleared areas, resistance to erosion, low. Establishment of vegetation, easy to fairly difficult. |
| Pilchuck sand<br>Pilchuck fine sand<br>Pilchuck loamy fine sand<br>Pilchuck loamy sand<br>Pilchuck gravelly sand<br>Pilchuck gravelly loamy sand | Stability: low. Compacted permeability: semipervious to impervious. Shrink-swell potential: low. Piping hazard through: foundation - high; fill - high. Suitability: poor. | Permeability: subsoil, 5.0-10.0 in/hr; substrata, more than 10.0 in/hr. Not suitable. Rapid permeability. | Shearing strength: subsoil, low; substrata, low. Compacted permeability: semipervious to impervious. Compressibility: very slight. Stability: subsoil, low; substrata, low. Piping: high hazard. | Resistance to erosion, low to moderate. Establishment of vegetation, fairly difficult. |

Table 16. Soil features affecting engineering practices for water impoundments or disposal, Puget Sound Area (con.)

| Soil Series and Type | Dikes or Levees | Farm Ponds: Reservoir Area | Farm Ponds: Embankments | Terraces, Diversions and Waterways |
|---|---|---|---|---|
| Pilchuck fine sandy loam<br>Pilchuck sandy loam | Stability: low to moderate. Compacted permeability: pervious to semipervious. Shrink-swell potential: low. Piping hazard through: foundation - high to very high; fill - very high. Suitability: poor. | Permeability: subsoil, 5.0-10.0 in/hr; substrata, over 10.0 in/hr. Suitability: Rapid permeability. Not suitable. | Shearing strength: subsoil, low to high; substrata, high. Compacted permeability: pervious to semipervious. Compressibility: slight. Stability: subsoil, low to moderate; substrata, moderate. Piping: very high hazard. | Resistance to erosion, low to moderate. Establishment of vegetation, fairly difficult. |
| Pondilla fine sand | Stability: low. Compacted permeability: semipervious to impervious. Shrink-swell potential: low. Piping hazard through: fill - high. Suitability: good to poor when compacted with sheeps-foot roller. | Permeability: subsoil, 5.0-10.0 in/hr; substratum, 5.0-10.0 in/hr. Suitability: unsuitable. Soil permeability rapid. | Shearing strength: subsoil, low; substratum, low. Compacted permeability: semipervious to impervious. Compressibility: very slight to medium. Stability: subsoil, low; substratum, low. Piping: high hazard. | Resistance to erosion, low to moderate. Establishment of vegetation, fairly difficult. |
| Prather silty clay loam | Stability: moderate to low. Compacted permeability: semipervious to impervious. Shrink-swell potential: high; cracks when dry. Piping hazard through: fill - low to high. Suitability: poor to very poor. | Permeability: subsoil, 0.05-0.2 in/hr; substratum, less than 0.05 in/hr. Suitability: good. Cracks when dry. | Shearing strength: subsoil, very low; substratum, very low. Compacted permeability: semipervious to impervious. Cracks when dry. Compressibility: very high. Stability: subsoil, moderate; substratum, low. Piping: low to high. | Resistance to erosion, low. On tilled slopes over 3%. Establishment of vegetation, fairly easy. |
| Puget loam<br>Puget silt loam<br>Puget silty clay loam<br>Puget clay loam | Stability: low. Compacted permeability: semipervious to impervious. Shrink-swell potential: moderate to high. Piping hazard through: foundation - low to high; fill - low to high. Suitability: poor to very poor. | Permeability: subsoil, 0.2-0.8 in/hr; substrata, 0.05-0.2 in/hr. Suitability: good. | Shearing strength: subsoil, very low; substrata, very low. Compacted permeability: semipervious to impervious. Compressibility: medium to very high. Stability: subsoil, low; substrata, low. Piping: high hazard. | Resistance to erosion, low. Establishment of vegetation, fairly easy. |

Table 16. Soil features affecting engineering practices for water impoundments or disposal, Puget Sound Area (con.)

| Soil Series and Type | Dikes or Levees | Farm Ponds | | Terraces, Diversions and Waterways |
|---|---|---|---|---|
| | | Reservoir Area | Embankments | |
| Puget fine sandy loam<br>Puget very fine sandy loam | Stability: low. Compacted permeability: semipervious to impervious. Shrink-swell potential: moderate to low. Piping hazard through: foundation - high; fill - high. Suitability: good to poor when compacted with sheeps-foot roller. | Permeability: subsoil, 0.2-0.8 in/hr; substrata, 0.05-0.2 in/hr. Suitability: good. | Shearing strength: subsoil, low; substrata, low to very low. Compacted permeability: semipervious to impervious. Compressibility: very slight to medium. Stability: subsoil, low; substrata, low. Piping: high hazard. | Resistance to erosion, low to moderate. Establishment of vegetation, easy. |
| Puget clay<br>Puget silty clay | Stability: low. Compacted permeability: semipervious to impervious. Shrink-swell potential: high; cracks when dry. Piping hazard through: foundation - variable; low to high; fill - variable; low to high. Suitability: poor to very poor. | Permeability: subsoil, 0.2-0.8 in/hr; substrata, 0.05-0.2 in/hr. Suitability: good. | Shearing strength: subsoil, very low; substrata, very low. Compacted permeability: semipervious to impervious. Compressibility: very high; cracks when dry. Stability: subsoil, low; substrata, low. Piping: variable; low to high hazard. | Resistance to erosion, low. Establishment of vegetation, fairly easy. |
| Puyallup fine sandy loam<br>Puyallup sandy loam<br>Puyallup very fine sandy loam | Stability: low. Compacted permeability: semipervious to impervious. Shrink-swell potential: low to moderate. Piping hazard through: foundation - high; fill - high. Suitability: good to poor when compacted with sheeps-foot roller. | Permeability: subsoil, 0.8-2.5 in/hr; substrata, 5.0-10.0 in/hr. Suitability: poor. | Shearing strength: subsoil, low; substrata, low to very low. Compacted permeability: semipervious to impervious. Compressibility: very slight to medium. Stability: subsoil, low; substrata, low. Piping: high hazard. | Resistance to erosion, low. Establishment of vegetation, fairly easy. |
| Puyallup silt loam<br>Puyallup loam | Stability: low. Compacted permeability: semipervious to impervious. Shrink-swell potential: moderate to high. Piping hazard through: foundation - high, variable; fill - high to low, variable. Suitability: good to very poor when compacted with sheeps-foot roller. | Permeability: subsoil, 0.8-2.5 in/hr; substrata, 5.0-10.0 in/hr. Suitability: not suitable. | Shearing strength: subsoil, very low; substrata, very low. Compacted permeability: semipervious to impervious. Compressibility: medium to very high. Stability: subsoil, low; substrata, low. Piping: high hazard. | Resistance to erosion, low. Establishment of vegetation, fairly easy. |

Table 16. Soil features affecting engineering practices for water impoundments or disposal, Puget Sound Area (con.)

| Soil Series and Type | Dikes or Levees | Farm Ponds | | Terraces, Diversions and Waterways |
|---|---|---|---|---|
| | | Reservoir Area | Embankments | |
| Puyallup silty clay loam<br>Puyallup loamy sand/Puget | Stability: low.<br>Compacted permeability: semipervious to impervious.<br>Shrink-swell potential: moderate to low. Piping hazard through: foundation - high; fill - high. Suitability: good to poor when compacted with sheeps-foot roller. | Permeability: subsoil, 0.8-2.5 in/hr; substrata, 5.0-10.0 in/hr.<br>Suitability: not suitable. | Shearing strength: subsoil, low to very low; substrata, low to very low.<br>Compacted permeability: semipervious to impervious.<br>Compressibility: very slight to medium.<br>Stability: subsoil, low; substrata, low. | Resistance to erosion, low.<br>Establishment of vegetation, fairly easy. |
| Puyallup fine sandy loam/Buckley<br>Puyallup sandy loam/ Buckley<br>Puyallup loamy fine sand | Stability: low.<br>Compacted permeability: semipervious to impervious.<br>Shrink-swell potential: low to moderate.<br>Piping hazard through: foundation - high to moderately low; fill - high to moderately low. | Permeability: subsoil, 0.8-2.5 in/hr; substrata, 0.05-0.2 in/hr.<br>Suitability: fair to very good. | Shearing strength: subsoil, low; substrata, low.<br>Compacted permeability: semipervious to impervious.<br>Compressibility: very slight to medium.<br>Stability: subsoil, low; substrata, low.<br>Piping: variable. High to moderately low. | Puyallup fine sandy loam/ Buckley: Resistance to erosion, moderately low. Establishment of vegetation, fairly easy to difficult.<br>Puyallup sandy loam/Buckley and Puyallup loamy fine sand: Resistance to erosion, low.<br>Establishment of vegetation, fairly easy. |
| Quilcene silty clay loam | Stability: moderate to high.<br>Compacted permeability: impervious.<br>Shrink-swell potential: low to moderate. May crack when dry.<br>Piping hazard through: fill - moderately low to low.<br>Suitability: good to fair when compacted with sheeps-foot roller. | Permeability: subsoil, 0.2-0.8 in/hr; substratum, 0.05-0.2 in/hr.<br>Suitability: excellent. | Shearing strength: subsoil, very low; substratum, moderate.<br>Compacted permeability: impervious.<br>Compressibility: slight to medium. May crack when dry.<br>Stability: subsoil, moderate; substratum, high.<br>Piping: moderately low to low. | Resistance to erosion, moderate.<br>May reduce erosion and siltation from tilled slopes over 3%.<br>Establishment of vegetation, fairly easy. |
| Ragnar fine sandy loam | Stability: low to moderate.<br>Compacted permeability: pervious to impervious.<br>Shrink-swell potential: moderate to low.<br>Piping hazard through: fill - high to very high.<br>Suitability: very good to good when compacted with sheeps-foot roller. | Permeability: subsoil, 5.0-10.0 in/hr; substratum, 5.0-10.0 in/hr.<br>Suitability: not suitable.<br>Rapid permeability. | Shearing strength: subsoil, low to very low; substratum, high to low.<br>Compacted permeability: pervious to impervious.<br>Compressibility: very slight to medium.<br>Stability: subsoil, low; substratum, moderate to low. | Resistance to erosion, low.<br>Establishment of vegetation, fairly difficult. |

Table 16. Soil features affecting engineering practices for water impoundments or disposal, Puget Sound Area (con.)

| Soil Series and Type | Dikes or Levees | Farm Ponds | | Terraces, Diversions and Waterways |
|---|---|---|---|---|
| | | Reservoir Area | Embankments | |
| Reed clay<br>Reed silty clay loam | Stability: moderate. Compacted permeability: impervious. Shrink-swell potential: high to moderate. Cracks when dry. Piping hazard through: foundation - low; fill - low. Suitability: poor to very poor. | Permeability: subsoil, less than 0.05 in/hr; substrata, less than 0.05 in/hr. Suitability: good. | Shearing strength: subsoil, very low; substrata, very low. Compacted permeability: impervious. Compressibility: high to very high. Stability: subsoil, moderate; substrata, moderate. Piping: low. | Resistance to erosion, moderate to high. Establishment of vegetation, fairly difficult. |
| Riverwash | Stability: high. Compacted permeability: very pervious. Shrink-swell potential: low. Piping hazard through: foundation - very high; fill - very high. Suitability: poor. | Permeability: subsoil, 5.0-10.0 in/hr; substratum, 5.0-10.0 in/hr. Not suitable. | Shearing strength: subsoil, high; substratum, high. Compacted permeability: pervious. Compressibility: very slight. Stability: subsoil, high; substratum, high. Piping: high hazard. | Resistance to erosion, high. Establishment of vegetation, difficult. |
| Roche gravelly loam<br>Roche stony loam<br>Roche/Rock land* complex<br>(*see Rock land)<br>Roche/Rock (outcrop) complex | Stability: high to low. Compacted permeability: semipervious to impervious. Shrink-swell potential: low to moderate. Piping hazard through: fill - high to moderately low. Suitability: good to poor when compacted with sheeps-foot roller. | Permeability: subsoil, 0.05-0.2 in/hr; substrata, less than 0.05 in/hr. Suitability: well suited. | Shearing strength: subsoil, low to moderate; substrata, low. Compacted permeability: semipervious to impervious. Compressibility: very slight to medium. Stability: subsoil, low to high; substrata, moderate. Piping: high to moderately low hazard. | Resistance to erosion, low to moderate. May reduce erosion and siltation from tilled slopes over 3%. Establishment of vegetation, fairly difficult. |
| Roche stony sandy loam<br>Roche gravelly sandy loam<br>Roche loam | Stability: low. Compacted permeability: semipervious to impervious. Shrink-swell potential: low. Piping hazard through: fill - high. Suitability: good to poor when compacted with sheeps-foot roller. | Permeability: subsoil, 0.05-0.2 in/hr; substrata, less than 0.05 in/hr. Suitability: well suited. | Shearing strength: subsoil, low; substrata, low. Compacted permeability: semipervious to impervious. Compressibility: very slight to medium. Stability: subsoil, low; substrata, low. Piping: high hazard. | Resistance to erosion, low to moderate. May reduce erosion and siltation from tilled slopes over 3%. Establishment of vegetation, fairly difficult. |
| Rock land<br>Rough mountainous land<br>Rough mountainous, Heisler soil material | Not suitable. | Bedrock at less than 6 feet. | Variable. | Resistance to erosion, variable, low to moderate. Diversions may be essential to reduce erosion and siltation. Establishment of vegetation, easy to fairly difficult. |

Table 16. Soil features affecting engineering practices for water impoundments or disposal, Puget Sound Area (con.)

| Soil Series and Type | Dikes or Levees | Farm Ponds: Reservoir Area | Farm Ponds: Embankments | Terraces, Diversions and Waterways |
|---|---|---|---|---|
| Puyallup silty clay loam<br>Puyallup loamy sand/Puget | Stability: low.<br>Compacted permeability: semipervious to impervious.<br>Shrink-swell potential: moderate to low. Piping hazard through: foundation - high; fill - high. Suitability: good to poor when compacted with sheeps-foot roller. | Permeability: subsoil, 0.8-2.5 in/hr; substrata, 5.0-10.0 in/hr.<br>Suitability: not suitable. | Shearing strength: subsoil, low to very low; substrata, low to very low.<br>Compacted permeability: semipervious to impervious.<br>Compressibility: very slight to medium.<br>Stability: subsoil, low; substrata, low. | Resistance to erosion, low.<br>Establishment of vegetation, fairly easy. |
| Puyallup fine sandy loam/Buckley<br>Puyallup sandy loam/ Buckley<br>Puyallup loamy fine sand | Stability: low.<br>Compacted permeability: semipervious to impervious.<br>Shrink-swell potential: low to moderate.<br>Piping hazard through: foundation - high to moderately low; fill - high to moderately low. | Permeability: subsoil, 0.8-2.5 in/hr; substrata, 0.05-0.2 in/hr.<br>Suitability: fair to very good. | Shearing strength: subsoil, low; substrata, low.<br>Compacted permeability: semipervious to impervious.<br>Compressibility: very slight to medium.<br>Stability: subsoil, low; substrata, low.<br>Piping: variable. High to moderately low. | Puyallup fine sandy loam/ Buckley: Resistance to erosion, moderately low. Establishment of vegetation, fairly easy to difficult.<br>Puyallup sandy loam/Buckley and Puyallup loamy fine sand: Resistance to erosion, low. Establishment of vegetation, fairly easy. |
| Quilcene silty clay loam | Stability: moderate to high.<br>Compacted permeability: impervious.<br>Shrink-swell potential: low to moderate. May crack when dry.<br>Piping hazard through: fill - moderately low to low.<br>Suitability: good to fair when compacted with sheeps-foot roller. | Permeability: subsoil, 0.2-0.8 in/hr; substratum, 0.05-0.2 in/hr.<br>Suitability: excellent. | Shearing strength: subsoil, very low; substratum, moderate.<br>Compacted permeability: impervious.<br>Compressibility: slight to medium. May crack when dry.<br>Stability: subsoil, moderate; substratum, high.<br>Piping: moderately low to low. | Resistance to erosion, moderate.<br>May reduce erosion and siltation from tilled slopes over 3%.<br>Establishment of vegetation, fairly easy. |
| Ragnar fine sandy loam | Stability: low to moderate.<br>Compacted permeability: pervious to impervious.<br>Shrink-swell potential: moderate to low.<br>Piping hazard through: fill - high to very high.<br>Suitability: very good to good when compacted with sheeps-foot roller. | Permeability: subsoil, 5.0-10.0 in/hr; substratum, 5.0-10.0 in/hr.<br>Suitability: not suitable.<br>Rapid permeability. | Shearing strength: subsoil, low to very low; substratum, high to low.<br>Compacted permeability: pervious to impervious.<br>Compressibility: very slight to medium.<br>Stability: subsoil, low; substratum, moderate to low. | Resistance to erosion, low.<br>Establishment of vegetation, fairly difficult. |

Table 16. Soil features affecting engineering practices for water impoundments or disposal, Puget Sound Area (con.)

| Soil Series and Type | Dikes or Levees | Farm Ponds | | Terraces, Diversions and Waterways |
|---|---|---|---|---|
| | | Reservoir Area | Embankments | |
| Rough broken Land | | See soils for adjoining areas. | | Resistance to erosion, variable, from low to high. Terraces and diversions may be beneficial in reducing erosion and sedimentation from these areas. Establishment of vegetation, variable. |
| Rough stony land | | See soils for adjoining areas. | | Resistance to erosion, high. Soils generally shallow to very shallow over bedrock. Terraces and diversions may be beneficial in reducing erosion and sedimentation from these areas. Establishment of vegetation, difficult. |
| Rough broken land<br>Olympic soil materials | Stability: moderate to low. Compacted permeability: semipervious to impervious. Shrink-swell potential: moderate to low. Cracks when dry. Piping hazard through: fill - not suitable. Basalt bedrock at 2 to 5 feet or more. | Permeability: subsoil, 0.2-0.8 in/hr; substrata, 0.2-0.8 in/hr. Basalt bedrock at 2 to 5 feet or more. Suitability: good to poor. | Shearing strength: subsoil, very low; substrata, very low. Compacted permeability: semipervious to impervious. Compressibility: medium to high. Stability: subsoil, low; substrata, moderate. | Resistance to erosion, low to moderate. Establishment of vegetation, fairly easy. |
| Salal fine sandy loam<br>Salal silt loam | Stability: low. Compacted permeability: semipervious to impervious. Shrink-swell potential: moderate to low. Piping hazard through: foundation - high; fill - high. Suitability: good to poor. Material may be micaceous and unstable. | Permeability: subsoil, 0.2-0.8 in/hr; substrata, 0.8-2.5 in/hr. Suitability: poor. | Shearing strength: subsoil, low, substrata, very low. Compacted permeability: semipervious to impervious. Compressibility: very slight to medium. Stability: subsoil, low; substrata, low. Piping: high hazard. | Resistance to erosion, low. Establishment of vegetation, fairly easy. |

Table 16. Soil features affecting engineering practices for water impoundments or disposal, Puget Sound Area (con.)

| Soil Series and Type | Dikes or Levees | Farm Ponds | | Terraces, Diversions and Waterways |
|---|---|---|---|---|
| | | Reservoir Area | Embankments | |
| Samish silt loam<br>Samish silty clay loam | Stability: low. Compacted permeability: semipervious to impervious. Shrink-swell potential: moderate to high. Cracks when dry. Piping hazard, through: foundation - variable; low to high; fill - variable; low to high. Soils are micaceous and unstable. Suitability: poor. | Permeability: subsoil, 0.2-0.8 in/hr; substrata, 0.05-0.2 in/hr. Suitability: fair. | Shearing strength: subsoil, very low; substrata, very low. Compacted permeability: semipervious to impervious. Compressibility: medium to very high. Stability: subsoil, low; substrata, low. Piping: variable, low to high hazard. | Resistance to erosion, low. Establishment of vegetation, easy. |
| Sammamish silt loam | Stability: low. Compacted permeability: semipervious to impervious. Shrink-swell potential: moderate to high. Cracks when dry. Piping hazard through: foundation - variable; low to high; fill - variable; low to high. Suitability: good to very poor. Cracks when dry. | Permeability: subsoil, 0.05-0.2 in/hr; substratum, 0.05-0.2 in/hr. Suitability: good. | Shearing strength: subsoil, very low; substratum, very low. Compacted permeability: semipervious to impervious. Compressibility: medium to very high. Stability: subsoil, low; substratum, low. Piping: variable, low to high. | Resistance to erosion, low. Establishment of vegetation, fairly easy. |
| San Juan coarse sandy loam<br>San Juan gravelly sandy loam<br>San Juan stony sandy loam | Stability: high to moderate. Compacted permeability: pervious. Shrink-swell potential: low. Piping hazard through: fill - very high. Suitability: good when compacted with crawler tractor. | Permeability: subsoil, 5.0-10.0 in/hr; substrata, 5.0-10.0 in/hr. Not suitable. | Shearing strength: subsoil, high; substrata, very high. Compacted permeability: pervious. Compressibility: very slight. Stability: subsoil, high to moderate; substrata, high to moderate. Piping: very high hazard. | Resistance to erosion: San Juan coarse sandy loam, very high; San Juan gravelly sandy loam and San Juan stony sandy loam, moderate. Establishment of vegetation, difficult. |
| San Juan gravelly sandy loam, moderately deep/glacial till<br>San Juan loam, moderately deep/glacial till<br>San Juan stony loam, moderately deep/glacial till | Stability: high to low. Compacted permeability: impervious. Shrink-swell potential: moderate to low. Piping hazard through: fill - low to moderately low. Suitability: good to fair when compacted with sheepsfoot roller. | Permeability: subsoil, 0.8-2.5 in/hr; substrata, 0.05-0.2 in/hr. Suitability: fair to good. | Shearing strength: subsoil, high to low; substrata, very low. Compacted permeability: impervious. Compressibility: slight to medium. Stability: subsoil, low to high; substrata, high to moderate. Piping: low to moderately low. | Resistance to erosion, low to moderate. May be used to reduce erosion and sedimentation on slopes greater than 8%. Establishment of vegetation, fairly difficult. |

Table 16. Soil features affecting engineering practices for water impoundments or disposal, Puget Sound Area (con.)

| Soil Series and Type | Dikes or Levees | Farm Ponds | | Terraces, Diversions and Waterways |
|---|---|---|---|---|
| | | Reservoir Area | Embankments | |
| Sauk loam | Stability: low. Compacted permeability: semipervious to impervious. Shrink-swell potential: moderate to low. Piping hazard through: fill - high. Suitability: good to poor when compacted with sheeps-foot roller. | Permeability: subsoil, 0.8-2.5 in/hr; substratum, 2.5-5.0 in/hr. Suitability: fair to poor. | Shearing strength: subsoil, very low; substratum, low. Compacted permeability: semipervious to impervious. Compressibility: very slight to medium. Stability: subsoil, low; substratum, low. Piping: high hazard. | Resistance to erosion, low. Establishment of vegetation, easy. |
| Saxon silt loam | Stability: low. Compacted permeability: semipervious to impervious. Shrink-swell potential: moderately low to low. Piping hazard through: fill - high. Suitability: good to poor when compacted with sheeps-foot roller. | Permeability: subsoil, 0.2-0.8 in/hr; substratum, 0.05-0.2 in/hr. Cemented gravelly silty clay glacial till at 3 to 4 feet. | Shearing strength: subsoil, very low; substratum, low. Compacted permeability: semipervious to impervious. Compressibility: very slight to medium. Stability: subsoil, low; substratum, low. Piping: high to low hazard. | Resistance to erosion, low to moderate. May be used on tilled slopes over 8% to reduce the hazard of erosion and sedimentation. Establishment of vegetation, fairly easy. |
| Schnorbush loam<br>Schnorbush loam/Norma* silty clay loam complex (*see Norma silty clay loam) | Stability: high. Compacted permeability: very pervious. Shrink-swell potential: low to moderate. Piping hazard through: fill - moderately low. Suitability: fair when compacted with sheeps-foot roller. | Permeability: subsoil, 0.2-0.8 in/hr; substrata, 0.2-0.8 in/hr. Suitability: very good. | Shearing strength: subsoil, moderate; substrata, moderate. Compacted permeability: very pervious. Compressibility: slight. Stability: subsoil, low; substrata, low. Piping: moderately low. | Resistance to erosion, moderate. Should be used on slopes in excess of 3% if the land is tilled. Establishment of vegetation, fairly difficult. |
| Schooley loam | Stability: low to moderate. Compacted permeability: semipervious to impervious. Shrink-swell potential: low to high. Cracks when dry. Piping hazard through: fill - variable; low to high. Suitability: very poor. | Permeability: subsoil, 2.5-5.0 in/hr; substratum, less than 0.05 in/hr. Suitability: fair to good. | Shearing strength: subsoil, low; substratum, very low. Compacted permeability: semipervious to impervious. Compressibility: very slight to very high. Cracks when dry. Stability: subsoil, low; substratum, moderate. Piping: variable; low to high hazard. | Resistance to erosion, moderate. Establishment of vegetation, fairly difficult. |

Table 16. Soil features affecting engineering practices for water impoundments or disposal, Puget Sound Area (con.)

| Soil Series and Type | Dikes or Levees | Farm Ponds | | Terraces, Diversions and Waterways |
|---|---|---|---|---|
| | | Reservoir Area | Embankments | |
| Semiahmoo | Stability: unstable. Not suitable. Low strength. Compacted permeability: not suitable. Low volume weight. Shrink-swell potential: very high. Not suitable. Cracks when dry. Piping hazard through: foundation - not suitable; fill - not suitable. Remove from base. Not suitable. | Permeability: subsoil, 0.8-2.5 in/hr; substratum, variable, 0.2-2.5 in/hr. | Shearing strength: subsoil - not suitable. Low volume weight. Low strength. | Resistance to erosion, low. Establishment of vegetation, easy. |
| Sequim clay loam<br>Sequim gravelly loam | Stability: high. Compacted permeability: very pervious to impervious. Shrink-swell potential: low to moderate. Piping hazard through: fill - moderately low to very high. | Permeability: subsoil, 0.8-2.5 in/hr; substrata, 0.2-0.8 in/hr. Suitability: good to poor. | Shearing strength: subsoil, moderate; substrata, moderate to high. Compacted permeability: very pervious to impervious. Compressibility: slight to very slight. Stability: subsoil, high; substrata, high. Piping: moderately low to very high. | Resistance to erosion, moderate. Establishment of vegetation, fairly difficult. |
| Shelton gravelly loam<br>Shelton gravelly sandy loam | Stability: high to low. Compacted permeability: semipervious to impervious. Shrink-swell potential: low. Piping hazard through: fill - high. Suitability: good to poor when compacted with sheepsfoot roller. | Permeability: subsoil, 0.8-2.5 in/hr; substrata, 0.05-0.2 in/hr. Suitability: good. Cemented glacial till at 2½ to 4 feet. | Shearing strength: subsoil moderate; substrata, low. Compacted permeability: semipervious to impervious. Compressibility: very slight to medium. Stability: subsoil, high; substrata, high to low. Piping: high hazard. | Resistance to erosion, moderate. Will reduce erosion hazard and sedimentation on tilled slopes above 3%. Establishment of vegetation, fairly difficult. |
| Shuwah silty clay loam | Stability: moderate. Compacted permeability: impervious. Cracks when dry. Shrink-swell potential: high. Piping hazard through: foundation - low to high; fill - low to high. Suitability: very poor. | Permeability: subsoil, 0.2-0.8 in/hr; substratum, 0.2-0.8 in/hr. Suitability: good. | Shearing strength: subsoil, very low; substratum, very low. Compacted permeability: impervious. Cracks when dry. Compressibility: very high. Stability: subsoil, moderate; substratum, moderate. Piping: low to high hazard. | Resistance to erosion, moderate. Establishment of vegetation, fairly easy. |

Table 16. Soil features affecting engineering practices for water impoundments or disposal, Puget Sound Area.

| Soil Series and Type | Dikes or Levees | Farm Ponds | | Terraces, Diversions and Waterways |
|---|---|---|---|---|
| | | Reservoir Area | Embankments | |
| Sinclair clay loam<br>Sinclair shotty loam<br>Sinclair gravelly loam<br>Sinclair gravelly clay loam<br>Sinclair gravelly fine sandy loam<br>Sinclair gravelly sandy loam | Stability: low.<br>Compacted permeability: semipervious to impervious.<br>Shrink-swell potential: low.<br>Piping hazard through: fill - high.<br>Suitability: good to poor when compacted with sheepsfoot roller. | Permeability: subsoil, 0.2-0.8 in/hr; substrata, 0.05-0.2 in/hr.<br>Firmly cemented gravelly sandy loam glacial till at $2\frac{1}{2}$ to 3 feet.<br>Suitability: fair. | Shearing strength: subsoil, low; substrata, low.<br>Compacted permeability: semipervious to impervious.<br>Compressibility: very slight to medium.<br>Stability: subsoil, low; substrata, low.<br>Piping: high hazard. | Resistance to erosion, moderate.<br>Establishment of vegetation, fairly difficult to difficult.<br>Sinclair clay loam, Sinclair shotty loam, Sinclair gravelly loam, and Sinclair gravelly clay loam, if tilled, on slopes above 3% to control erosion and reduce sedimentation.<br>Sinclair gravelly fine sandy loam and Sinclair gravelly sandy loam, if tilled, on slopes above 8% to control erosion and sedimentation. |
| Skagit silty clay loam | Stability: low.<br>Compacted permeability: semipervious to impervious.<br>Shrink-swell potential: moderate to low.<br>Piping hazard through: fill - high.<br>Suitability: good to poor when compacted with sheepsfoot roller. | Permeability: subsoil, less than 0.05 in/hr; substratum, less than 0.05 in/hr.<br>Suitability: good. | Shearing strength: subsoil, very low; substratum, very low.<br>Compacted permeability: semipervious to impervious.<br>Compressibility: medium.<br>Stability: subsoil, low; substratum, low.<br>Piping: high hazard. | Resistance to erosion, low.<br>Establishment of vegetation, fairly difficult. |
| Skiyou gravelly loam | Stability: low to high.<br>Compacted permeability: semipervious to impervious.<br>Shrink-swell potential: moderate to low.<br>Piping hazard through: fill - high.<br>Suitability: good to poor when compacted with sheepsfoot roller. | Permeability: subsoil, 0.2-0.8 in/hr; substratum, 0.05-0.2 in/hr.<br>Strongly cemented gravelly sandy loam glacial till at 2 to 3 feet.<br>Suitability: good to poor. | Shearing strength: subsoil, very low; substratum, moderate.<br>Compacted permeability: semipervious to impervious.<br>Compressibility: medium to very slight.<br>Stability: subsoil, low; substratum, high.<br>Piping: high hazard. | Resistance to erosion, low.<br>On tilled slopes over 3% to control erosion and sedimentation.<br>Establishment of vegetation, fairly difficult. |

Table 16. Soil features affecting engineering practices for water impoundments or disposal, Puget Sound Area (con.)

| Soil Series and Type | Dikes or Levees | Farm Ponds | | Terraces, Diversions and Waterways |
|---|---|---|---|---|
| | | Reservoir Area | Embankments | |
| Skokomish silt loam | Stability: low to moderate. Compacted permeability: semipervious to impervious. Shrink-swell potential: moderate to low. May crack when dry. Piping hazard through: Foundation - high to low; fill - high to low. Suitability: good to poor when compacted with sheepsfoot roller. | Permeability: subsoil, 0.2-0.8 in/hr; substratum, 0.05-0.2 in/hr. Suitability: good. | Shearing strength: subsoil, very low; substratum, low to very low. Compacted permeability: semipervious to impervious. Compressibility: very slight to high. May crack when dry. Stability: subsoil, low; substratum, low to moderate. Piping: high to low hazard. | Resistance to erosion, low. Establishment of vegetation, easy. |
| Skykomish cobbly sandy loam<br>Skykomish gravelly sandy loam<br>Skykomish gravelly loam<br>Skykomish stony loam | Stability: high. Compacted permeability: pervious to very pervious. Shrink-swell potential: low. Piping hazard through: fill - very high. Suitability: good for pervious shells. | Permeability: subsoil, 5.0-10.0 in/hr; substrata, over 10.0 in/hr. Not suitable. | Shearing strength: subsoil, high to very high; substrata, high to very high. Compacted permeability: pervious to very pervious. Compressibility: very slight. Stability: subsoil, high; substrata, high. Piping: very high hazard. | Resistance to erosion, high, to very high. Establishment of vegetation, difficult. |
| Skykomish stony sand<br>Skykomish gravelly sand | Stability: moderate to high. Compacted permeability: pervious. Shrink-swell potential: very low to low. Piping hazard through: fill - very high. Suitability: good for pervious shells. May need slope protection. | Permeability: subsoil, 5.0-10.0 in/hr; substrata, 5.0-10.0 in/hr. Not suitable. | Shearing strength: subsoil, very high; substrata, very Compacted permeability: pervious. Compressibility: very slight. Stability: subsoil, moderate to high; substrata, moderate to high. Piping: fair to good. | Resistance to erosion, moderate. Establishment of vegetation, difficult. |
| Smith Creek gravelly loam | Stability: low to moderate. Compacted permeability: pervious to impervious. Shrink-swell potential: low. Piping hazard through: fill - high to very high. Suitability: good to poor. | Permeability: subsoil, 0.8-2.5 in/hr; substratum, variable, 2.5-10.0 in/hr. Not suitable. | Shearing strength: subsoil, low; substratum, high. Compacted permeability: pervious to impervious. Compressibility: very slight to medium. Stability: subsoil, low; substratum, moderate. Piping: high to very high hazard. | Resistance to erosion, low to moderate. Establishment of vegetation, difficult. |

Table 16. Soil features affecting engineering practices for water impoundments or disposal, Puget Sound Area (con.)

| Soil Series and Type | Dikes or Levees | Farm Ponds | | Terraces, Diversions and Waterways |
|---|---|---|---|---|
| | | Reservoir Area | Embankments | |
| Snakelum coarse sandy loam | Stability: low to moderate. Compacted permeability: pervious to impervious. Shrink-swell potential: low. Piping hazard through: fill - high to very high. Suitability: good to poor. | Permeability: subsoil, 5.0-10.0 in/hr; substratum, 5.0-10.0 in/hr. Not suitable. | Shearing strength: subsoil, low; substratum, high. Compacted permeability: pervious to impervious. Compressibility: very slight to medium. Stability: subsoil, low; substratum, moderate. Piping: high to very high hazard. | Resistance to erosion, low to moderate. Establishment of vegetation, difficult. |
| Snohomish fine sandy loam<br>Snohomish loamy fine sand<br>Snohomish loam<br>Snohomish silt loam | Stability: low. Compacted permeability: semipervious to impervious. Shrink-swell potential: moderate to low. Piping hazard through: foundation - very high; fill - very high. Suitability: fair to not suitable. Remove peat, otherwise not suitable. | Permeability: subsoil, 0.2-0.8 in/hr; substrata, 0.2-0.8 in/hr. Not suitable. | Shearing strength: subsoil, low to very low; substrata, peat. Compacted permeability: semipervious to impervious. Compressibility: very slight to medium, mineral; peat, very high. Stability: subsoil, low; substrata, unsuitable. Peat. Piping; very high hazard. | Resistance to erosion, low. Establishment of vegetation, easy. |
| Snohomish silty clay<br>Snohomish silty clay loam | Stability: moderate to very low. Compacted permeability: impervious. Cracks. Shrink-swell potential: high. Piping hazard through: foundation - very high; fill - very high to low. Remove peat. | Permeability: subsoil, 0.2-0.8 in/hr; substrata, 0.2-0.8 in/hr. Not suitable. | Shearing strength: subsoil, very low; substrata, peat, unstable. Compacted permeability: impervious. Cracks. Compressibility: very high. Cracks. Stability: subsoil, moderate; substrata, unsuitable. Piping: very high hazard. | Resistance to erosion, low to moderate. Establishment of vegetation, easy. |
| Snoqualmie gravelly loam | Stability: low. Compacted permeability: semipervious to impervious. Shrink-swell potential: low. Piping hazard through: fill - high. Suitability: good to poor when compacted with sheepsfoot roller. | Permeability: subsoil, 2.5-5.0 in/hr; substratum, 5.0-10.0 in/hr. Not suitable. | Shearing strength: subsoil, low; substratum, low. Compacted permeability: semipervious to impervious. Compressibility: very slight. Stability: subsoil, low; substratum, low. Piping: high hazard. | Resistance to erosion, moderate to very high. Establishment of vegetation, difficult to fairly difficult. |

Table 16. Soil features affecting engineering practices for water impoundments or disposal, Puget Sound Area (con.)

| Soil Series and Type | Dikes or Levees | Farm Ponds | | Terraces, Diversions and Waterways |
|---|---|---|---|---|
| | | Reservoir Area | Embankments | |
| Snoqualmie gravelly sandy loam<br>Snoqualmie gravelly loamy sand | Stability: low to high. Compacted permeability: pervious to semipervious. Shrink-swell potential: low. Piping hazard through: fill - high to very high. Suitability: use only for pervious shell. | Permeability: subsoil, 2.5-5.0 in/hr; substrata, 5.0-10.0 in/hr. Not suitable. | Shearing strength: subsoil, low; substrata, very high. Compacted permeability: pervious to semipervious. Compressibility: very slight. Stability: subsoil, low; substrata, high. Piping: high to very high hazard. | Resistance to erosion, moderate to very high. Establishment of vegetation, fairly difficult to difficult. |
| Sol Duc gravelly loam<br>Sol Duc gravelly sandy loam | Stability: low to high. Compacted permeability: very pervious to impervious. Shrink-swell potential: low. Piping hazard through: fill - high to very high. Suitability: good to poor when compacted. | Permeability: subsoil, 2.5-5.0 in/hr; substrata, 5.0-10.0 in/hr. Not suitable. | Shearing strength: subsoil, low; substrata, high to very high. Compacted permeability: very pervious to impervious. Compressibility: very slight to medium. Stability: subsoil, low; substrata, high. Piping: high to very high hazard. | Resistance to erosion, moderate to high. Establishment of vegetation: fairly difficult to difficult. |
| Spalding peat<br>Spalding peat, burned | Not suitable. Low volume weight. Low strength. | Not suitable. | Not suitable. Low volume weight. Low strength. | Spalding peat resistance to erosion, low; establishment of vegetation, fairly easy. Burned: resistance to erosion, moderate; establishment of vegetation, very difficult. |
| Spanaway gravelly sandy loam<br>Spanaway stony sandy loam<br>Spanaway stony loam | Stability: high. Compacted permeability: pervious to semipervious. Shrink-swell potential: low. Piping hazard through: fill - very high to high. Suitability: good if used for pervious shell. May need slope protection. | Permeability: subsoil, 5.0-10.0 in/hr; substrata, more than 10.0 in/hr. Not suitable. | Shearing strength: subsoil, very high to moderate; substrata, very high. Compacted permeability: pervious to semipervious. Compressibility: very slight. Stability: subsoil, high; substrata, high. Piping: very high hazard. | Resistance to erosion, very high. Establishment of vegetation, difficult. |
| Squalicum silt loam | Stability: low to moderate. Compacted permeability: semipervious to impervious. Shrink-swell potential: moderate to low. Piping hazard through: fill - low. Suitability: good to poor when compacted with sheeps-foot roller. | Permeability: subsoil, 0.2-0.8 in/hr; substratum, less than 0.05 in/hr. Suitability: good. May crack when dry. | Shearing strength: subsoil, moderate to low; substratum, moderate; cracks when dry. Compacted permeability: semipervious to impervious. Compressibility: medium to high. Stability: subsoil, low; substratum, moderate. Piping: low to high hazard. | Resistance to erosion, low. On tilled slopes over 8% to reduce erosion and sedimentation. Establishment of vegetation, fairly difficult. |

Table 16. Soil features affecting engineering practices for water impoundments or disposal, Puget Sound Area (con.)

| Soil Series and Type | Dikes or Levees | Farm Ponds | | Terraces, Diversions and Waterways |
|---|---|---|---|---|
| | | Reservoir Area | Embankments | |
| Squalicum/Alderwood silt loams<br>Squalicum gravelly silt loam<br>Squalicum stony silt loam<br>Squalicum/Alderwood stony silt loam | Stability: low. Compacted permeability: semipervious to impervious: Shrink-swell potential: low. Piping hazard through: fill - high. Suitability: good to poor when compacted with sheeps-foot roller. | Permeability: subsoil, 0.2-0.8 in/hr; substrata, less than 0.05 in/hr. Suitability: fair. | Shearing strength: subsoil, low; substrata, low. Compacted permeability: semipervious to impervious. Compressibility: very slight to medium. Stability: subsoil, low; substrata, low. Piping: high hazard. | Resistance to erosion, low. On tilled slopes over 8% to reduce erosion and sedimentation. Establishment of vegetation, fairly difficult. |
| Steep broken land (see adjacent Alderwood, Everett, Kitsap or Indianola soils)* | | | | May be beneficial to reduce erosion and sediments. Resistance to erosion, variable. (*see adjacent soils.) |
| Stossel clay loam<br>Stossel stony loam | Stability: high to moderate. Compacted permeability: semipervious to impervious. Cracks when dry. Shrink-swell potential: low to moderate. Piping hazard through: fill - high to low. Suitability: good to fair when compacted with sheeps-foot roller. | Permeability: subsoil, 0.05-0.2 in/hr; substrata, less than 0.05 in/hr. Suitability: good. May crack when dry. | Shearing strength: subsoil, moderate; substrata, low. Compacted permeability: semipervious to impervious. Compressibility: very slight to high. Stability: subsoil, high; substrata, moderate. Piping: high to low hazard. | Resistance to erosion, moderate. Establishment of vegetation, fairly difficult. |
| Sultan silt loam<br>Sultan loam<br>Sultan clay loam | Stability: low to moderate. Compacted permeability: semipervious to impervious. Shrink-swell potential: moderate to low. Piping hazard through: foundation - variable, high. Suitability: good to poor when compacted with sheeps-foot roller. | Permeability: subsoil, 0.2-0.8 in/hr; substrata, 0.8-2.5 in/hr. Suitability: good to poor. | Shearing strength: subsoil, very low; substrata, low to very low. Compacted permeability: semipervious to impervious. Compressibility: very slight to medium. Stability: subsoil, low to moderate; substrata, low to moderate. Piping: variable, high hazard dominant. | Sultan silt loam and Sultan loam: Resistance to erosion, low; establishment of vegetation, easy. Sultan clay loam: Resistance to erosion, moderate. Establishment of vegetation, fairly easy. |
| Sultan fine sandy loam<br>Sultan loamy sand<br>Sultan sandy loam | Stability: low. Compacted permeability: semipervious to impervious. Shrink-swell potential: moderate to low. Piping hazard through: foundation - high; fill - high. Suitability: good to poor when compacted with sheeps-foot roller. | Permeability: subsoil, 0.2-0.8 in/hr; substrata, 0.8-2.5 in/hr. Suitability: fair to poor. | Shearing strength: subsoil, low; substrata, very low. Compacted permeability: semipervious to impervious. Compressibility: very slight to medium. Stability: subsoil, low; substrata, low. Piping: high hazard. | Resistance to erosion, low. Establishment of vegetation, fairly easy to easy. |

Table [illegible]. Soil features affecting engineering practices for water impoundments or disposal, Puget Sound Area (con.)

| Soil Series and Type | Dikes or Levees | Farm Ponds: Reservoir Area | Farm Ponds: Embankments | Terraces, Diversions and Waterways |
|---|---|---|---|---|
| Sultan silt loam, shallow/Buckley<br>Sultan silt loam, moderately deep/Buckley | Stability: low.<br>Compacted permeability: semipervious to impervious.<br>Shrink-swell potential: moderate to low. Piping hazard through: fill - high hazard.<br>Suitability: good to poor when compacted with sheeps-foot roller. | Permeability: subsoil, 0.8-2.5 in/hr; substratum, less than 0.05 in/hr.<br>Suitability: fair. Dense cemented sandy loam glacial till at 2 to 3 feet. | Shearing strength: subsoil, very low; substratum, low.<br>Compacted permeability: semipervious to impervious.<br>Compressibility: very slight to medium.<br>Stability: subsoil, low; substratum, low.<br>Piping: high hazard. | Resistance to erosion, low.<br>Establishment of vegetation, fairly easy. |
| Sumas silt loam<br>Sumas fine sandy loam | Stability: low to moderate.<br>Compacted permeability: subsoil, semipervious to impervious; substrata, pervious.<br>Shrink-swell potential: high to very low. Piping hazard through: foundation - very high; fill - variable, low to high. Suitability: good to poor when compacted with sheeps-foot roller. | Permeability: subsoil, 0.2-0.8 in/hr; substrata, 0.2-0.8 in/hr.<br>Suitability: not suitable. | Shearing strength: subsoil, very low; substrata, very high.<br>Compacted permeability: subsoil, semipervious to impervious; substrata, pervious.<br>Compressibility: very high to very slight.<br>Stability: subsoil, low; substrata, moderate.<br>Piping: variable, low to high hazard. | Resitance to erosion, low.<br>Establishment of vegetation, fairly easy. |
| Sumas silty clay loam | Stab lity: low.<br>Compacted permeability: semipervious to impervious.<br>Shrink-swell potential: high to low.<br>Piping hazard through: foundation - variable, low to high; fill - variable, low to high. | Permeability: subsoil, 0.2-0.8 in/hr; substratum, 0.2-0.8 in/hr.<br>Not suitable. | Shearing strength: subsoil, very low; substratum, very low to low. Compacted permeability: semipervious to impervious. Compressibility: very slight to very high.<br>Stability: subsoil, low; substratum, low. Piping: variable, low to high hazard. | Resistance to erosion, low.<br>Establishment of vegetation, fairly easy. |
| Swantown gravelly loam<br>Swantown loam | Stability: low to moderate.<br>Compacted permeability: impervious to semipervious.<br>Shrink-swell potential: low to moderate.<br>Piping hazard through: fill - high to low.<br>Suitability: good to poor when compacted with sheeps-foot roller. | Permeability: subsoil, 0.2-0.8 in/hr; substrata, less than 0.05 in/hr.<br>Suitability: good.<br>May crack when dry. Dense, cemented gravelly loam glacial till at 2 to 3 feet. | Shearing strength: subsoil, very low; substrata, low.<br>Compacted permeability: impervious to semipervious.<br>Compressibility: very slight to high. Cracks when dry.<br>Stability: subsoil, moderate; substrata, low to moderate.<br>Piping: high to low. | Resistance to erosion, low to moderate.<br>If tilled, on slopes of more than 3% to reduce erosion and sedimentation.<br>Establishment of vegetation, fairly difficult. |

Table 16. Soil features affecting engineering practices for water impoundments or disposal, Puget Sound Area (con.)

| Soil Series and Type | Dikes or Levees | Farm Ponds: Reservoir Area | Farm Ponds: Embankments | Terraces, Diversions and Waterways |
|---|---|---|---|---|
| Swantown gravelly sandy loam | Stability: low to high. Compacted permeability: impervious to pervious. Shrink-swell potential: low. Piping hazard through: fill - high to very high. Suitability: good to poor when compacted. | Permeability: subsoil, 0.2-0.8 in/hr; substratum, less than 0.05 in/hr. Suitability: fair to not suitable. | Shearing strength: subsoil, low; substratum, low to very high. Compacted permeability: impervious to pervious. Compressibility: very slight to medium. Suitability: subsoil, low; substratum, low to high. Piping: high to very high hazard. | Resistance to erosion, low. On slopes of more than 3%, if tilled, to reduce erosion and sedimentation. Establishment of vegetation, fairly difficult. |
| Tacoma muck<br>Tacoma peat | Not suitable. | Low volume weight. | Low strength. Shrinks when dry. | Resistance to erosion, low. Establishment of vegetation, easy. |
| Tanwax peat<br>Tanwax peat, shallow/ Mukilteo peat | Not suitable. | Low volume weight. | Low strength. | Resistance to erosion, low. Establishment of vegetation, fairly easy. |
| Tanwax peat/glacial till | Organic layer not suitable. Glacial till: Stability: low. Compacted permeability: semipervious to impervious. Shrink-swell potential: low. Piping hazard through: fill - high. Suitability: good when compacted. | Organic layer not suitable. Glacial till: Permeability: subsoil, 0.8-2.5 in/hr; substratum, 0.05-0.2 in/hr. Well suited. Suitability: good to poor. | Organic layer low strength. Glacial till: Shearing strength: subsoil, moderate; substratum, low. Compacted permeability: semipervious to impervious. Compressibility: slight. Stability. subsoil, high; substratum, high. Piping: high hazard. | Organic layer: resistance to erosion, low. Establishment of vegetation, fairly easy. Glacial till: resistance to erosion, low to moderate. On tilled slopes over 3%. Establishment of vegetation, easy to fairly difficult. |
| Tebo gravelly loam<br>Tebo loam | Stability: low to moderate. Compacted permeability: impervious to semipervious. Shrink-swell potential: moderate to low. Cracks when dry. Piping hazard through: fill - low to high. Suitability: good to poor when compacted with sheepsfoot roller. | Permeability: subsoil, 0.2-0.8 in/hr; substrata, 0.05-0.2 in/hr. Suitability: fair to good. Basalt bedrock at 3 to 6 feet. | Shearing strength: subsoil, very low; substrata, very low. Compacted permeability: moderate to low. Cracks when dry. Compressibility: medium to high. Stability: subsoil, low; substrata, low. Piping: low to high hazard. | Resistance to erosion, low. May be required on cleared slopes over 3%. Establishment of vegetation, fairly easy. |

Table 16. Soil features affecting engineering practices for water impoundments or disposal, Puget Sound Area (con.)

| Soil Series and Type | Dikes or Levees | Farm Ponds: Reservoir Area | Farm Ponds: Embankments | Terraces, Diversions and Waterways |
|---|---|---|---|---|
| Tenino gravelly sandy loam | Stability: high. Compacted permeability: pervious to impervious. Shrink-swell potential: low. Piping hazard through: fill - very high to high. Suitability: good when compacted. | Permeability: subsoil, 0.8-2.5 in/hr; substratum, 0.2-0.8 in/hr. Suitability: not suitable to good. Weakly cemented glacial till at 2 to 3 feet. | Shearing strength: subsoil, moderate; substratum, moderate to very high. Compacted permeability: pervious to impervious. Compressibility: very slight. Stability: subsoil, high; substratum, high. Piping: very high to high hazard. | Resistance to erosion, high. May be required on cleared slopes over 8%. Establishment of vegetation, fairly difficult. |
| Thornton clay<br>Thornton silty clay loam | Stability: low. Compacted permeability: semipervious to impervious. Shrink-swell potential: moderate to low. Piping hazard through: fill - high. Suitability: good to fair. | Permeability: subsoil, less than 0.05 in/hr; substrata, less than 0.05 in/hr. Suitability: good to fair. | Shearing strength: subsoil, low; substrata, low. Compacted permeability: semipervious to impervious. Compressibility: medium. Stability: subsoil, low; substrata, low. Piping: high hazard. | Resistance to erosion, low. Establishment of vegetation, fairly difficult. |
| Thornwood gravelly loam<br>Thornwood gravelly sandy loam | Stability: high. Compacted permeability: pervious to semipervious. Shrink-swell potential: low. Piping hazard through: fill - very high. Suitability: good when compacted. | Permeability: subsoil, 2.5-5.0 in/hr; substrata, 5.0-10.0 in/hr. Not suitable. | Shearing strength: subsoil, very high; substrata, very high to moderate. Compacted permeability: pervious to semipervious. Compressibility: very slight. Stability: subsoil, high; substrata, high. Piping: very high hazard. | Resistance to erosion, very high. To reduce erosion and sedimentation on cleared slopes over 15%. Establishment of vegetation, difficult. |
| Tidal marsh | Stability: low. Compacted permeability: semipervious to impervious. Shrink-swell potential: moderate to low. Cracks when dry. Piping hazard through: foundation - high; fill - high. | Permeability: subsoil, 0.2-0.5 in/hr; substratum, 0.05-0.2 in/hr. | Not suitable. | Resistance to erosion, low. Establishment of vegetation, difficult. |
| Tisch silt loam<br>Tisch silty clay loam | Stability: low to moderate. Compacted permeability: semipervious to impervious. Shrink-swell potential: high to low. Cracks when dry. Piping hazard through: foundation - variable, low to high; fill - variable, low to high. Suitability: poor to very poor. | Permeability: subsoil, 0.05-0.2 in/hr; substrata, 0.05-0.2 in/hr. Suitability: fair to good. | Shearing strength: subsoil, very low; substrata, very low to low. Compacted permeability: semipervious to impervious. Compressibility: very high to medium. Cracks when dry. Stability: subsoil, low to moderate; substrata, low. Piping: variable, low to high hazard. | Resistance to erosion, low. Establishment of vegetation, fairly difficult. |

Table 16. Soil features affecting engineering practices for water impoundments or disposal, Puget Sound Area (con.)

| Soil Series and Type | Dikes or Levees | Farm Ponds | | Terraces Diversions and Waterways |
|---|---|---|---|---|
| | | Reservoir Area | Embankments | |
| Tokul gravelly sandy loam | Stability: low. Compacted permeability: semipervious to impervious. Shrink-swell potential: low. Piping hazard through: fill - high. Suitability: fair when compacted with sheeps-foot roller. | Permeability: subsoil, 0.8-2.5 in/hr; substratum, 0.05-0.2 in/hr. Suitability: fair. Cemented gravelly sandy glacial till at 3 to 4 feet. | Shearing strength: subsoil, low; substratum, low. Compacted permeability: semipervious to impervious. Compressibility: very slight to medium. Stability: subsoil, low; substratum, low. Piping: high hazard. | Resistance to erosion, low. On cleared areas to protect water quality. Establishment of vegetation, fairly difficult. |
| Townsend loam<br>Townsend gravelly loam<br>Townsend fine sandy loam<br>Townsend sandy loam | Stability: high to low. Compacted permeability: pervious to impervious. Shrink-swell potential: low. Piping hazard through: fill - high to very high. Suitability: good when compacted. | Permeability: subsoil, 0.2-0.8 in/hr; substrata, 0.05-0.2 in/hr. Suitability: fair. | Shearing strength: subsoil, low; substrata, moderate to very high. Compacted permeability: pervious to impervious. Compressibility: very slight to medium. Stability: subsoil, low; substrata, high. Piping: high to very high hazard. | Resistance to erosion, low to moderate. Establishment of vegetation, fairly difficult. |
| Triton very gravelly loam | Stability: high. Compacted permeability: semipervious. Shrink-swell potential: low. Piping hazard through: fill - high. Suitability: good when compacted. | Permeability: subsoil, 0.8-2.5 in/hr; substratum, less than 0.05 in/hr. Basalt bedrock at shallow depths. | Shearing strength: subsoil, moderate, substratum, moderate. Compacted permeability: semipervious. Compressibility: very slight. Stability: subsoil, high; substratum, high. Piping: high hazard. | Resistance to erosion, moderate. Establishment of vegetation, difficult. |
| Tromp silt loam<br>Tromp silty clay loam<br>Tromp-Edmonds silt loams (see Edmonds silt loam)<br>Tromp-Custer silt loams (see Custer silt loam)<br>Tromp-Woodlyn silt loams (see Woodlyn silt loam) | Stability: low. Compacted permeability: semipervious to impervious. Shrink-swell potential: low. Piping hazard through: foundation - high; fill - high. Suitability: good to poor when compacted with sheeps-foot roller. | Permeability: subsoil, 0.05-0.2 in/hr; substrata, 0.8-2.5 in/hr. Suitability: good to poor. | Shearing strength: subsoil, low; substrata, low to very low. Compacted permeability: semipervious to impervious. Compressibility: very slight to medium. Stability: subsoil, low; substrata, low. Piping: high hazard. | Resistance to erosion, low. Establishment of vegetation, fairly difficult. |

Table 16. Soil features affecting engineering practices for water impoundments or disposal, Puget Sound Area (con.)

| Soil Series and Type | Dikes or Levees | Farm Ponds | | Terraces, Diversions and Waterways |
|---|---|---|---|---|
| | | Reservoir Area | Embankments | |
| Tromp-Tisch silt loams, complex (see Tisch silt loam) | Stability: low. Compacted permeability: semipervious to impervious. Shrink-swell potential: low to moderate. Piping hazard through: foundation - high; fill - high. Suitability: fair when compacted with sheeps-foot roller. | Permeability: subsoil, 0.05-0.2 in/hr; substrata, 0.05-0.2 in/hr. Suitability: very poor. | Shearing strength: subsoil, low to very low; substrata, low. Compacted permeability: semipervious to impervious. Compressibility: very slight to very high. Stability: subsoil, low; substrata, low. Piping: high hazard. | Resistance to erosion, low. Establishment of vegetation, fairly difficult. |
| Tumwater loamy fine sand<br>Tumwater fine sandy loam | Stability: low to moderate. Compacted permeability: pervious to semipervious. Shrink-swell potential: low. Piping hazard through: fill - high to very high. Suitability: poor. | Permeability: subsoil, 5.0-10.0 in/hr; substrata, 5.0-10.0 in/hr. Not suitable. | Shearing strength: subsoil, low; substrata, high to low. Compacted permeability: pervious to semipervious. Compressibility: very slight. Stability: subsoil, low; substrata, low to moderate. Piping: very high hazard. | Resistance to erosion, low. Establishment of vegetation, difficult. |
| Waddell loam<br>Waddell gravelly loam<br>Waddell silty clay loam | Stability: low. Compacted permeability: impervious. Cracks when dry. Shrink-swell potential: moderate. Cracks when dry. Piping hazard through: fill - low. Suitability: good to fair when compacted with sheeps-foot roller. | Permeability: subsoil, 0.8-2.5 in/hr; substrata, 0.2-0.8 in/hr. Suitability: good. | Shearing strength: subsoil, very low; substrata, very low. Compacted permeability: impervious. Cracks when dry. Compressibility: medium to high. Stability: subsoil, low; substrata, low. Piping: low hazard. | Resistance to erosion, moderate. Establishment of vegetation, fairly easy. |
| Wapato silty clay loam<br>Wapato clay loam<br>Wapato silty clay loam-Galvin silty clay loam complex<br>Wapato silt loam | Stability: moderate. Compacted permeability: impervious. Cracks when dry. Shrink-swell potential: moderate to high. Cracks when dry. Piping hazard through: foundation - variable, low to high; fill - variable, low to high. | Permeability: subsoil, 0.05-0.2 in/hr; substrata, less than 0.05 in/hr. Suitability: good. | Shearing strength: subsoil, very low; substrata, very low. Compacted permeability: impervious. Cracks when dry. Compressibility: very high. Cracks when dry. Stability: subsoil, moderate. substrata, moderate. Piping: variable, low to high. | Resistance to erosion, low to moderate. Establishment of vegetation, fairly easy. |

Table 16. Soil features affecting engineering practices for water impoundments or disposal, Puget Sound Area (con.)

| Soil Series and Type | Dikes or Levees | Farm Ponds: Reservoir Area | Farm Ponds: Embankments | Terraces, Diversions and Waterways |
|---|---|---|---|---|
| Whatcom silt loam<br>Whatcom silt loam-McKenna*<br>silty clay loam<br>complex (*see McKenna<br>silty clay loam) | Stability: moderate to low. Compacted permeability: semipervious to impervious. Shrink-swell potential: moderate to high. Cracks when dry. Piping hazard through: fill - low. Suitability: very poor. | Permeability: subsoil, 0.2-0.8 in/hr; substrata, less than 0.05 in/hr. Suitability: good to very poor. Cracks when dry. | Shearing strength: subsoil, very low; substrata, very low. Compacted permeability: semipervious to impervious. Compressibility: medium to very high. Stability: subsoil, moderate to low; substrata, moderate to low. Piping: low hazard. | Resistance to erosion, low to moderate. On tilled slopes over 3%. Establishment of vegetation, fairly easy. |
| Whidbey gravelly sandy loam | Stability: low to high. Compacted permeability: pervious to impervious. Shrink-swell potential: low. Piping hazard through: fill - high to very high. Suitability: good when compacted. | Permeability: subsoil, 5.0-10.0 in/hr; substratum, 0.05-0.2 in/hr. Suitability: fair to poor. | Shearing strength: subsoil, low, substratum, very high to low. Compacted permeability: pervious to impervious. Compressibility: very slight. Stability: subsoil, low; substratum, high to low. Piping: high to very high hazard. | Resistance to erosion, moderate to very high. Where tilled, on slopes over 8%. Establishment of vegetation, fairly difficult. |
| Wickersham shaly loam<br>Wickersham shaly silt loam | Stability: low to high. Compacted permeability: semipervious to very pervious. Shrink-swell potential: low. Piping hazard through: fill - high to very high. Suitability: good when compacted. | Permeability: subsoil, 2.5-5.0 in/hr; substrata, 2.5-5.0 in/hr. Not suitable. | Shearing strength: subsoil, low; substrata, low. Compacted permeability: semipervious to very pervious. Compressibility: very slight. Stability: subsoil, low; substrata, low. Piping: high to very high hazard. | Resistance to erosion, moderate to high. Establishment of vegetation, fairly difficult. |
| Wilkeson loam<br>Wilkeson silt loam | Stability: low. Compacted permeability: semipervious to impervious. Shrink-swell potential: low to moderate. Piping hazard through: fill - high. Suitability: good to poor when compacted with sheeps-foot roller. | Permeability: subsoil, 0.2-0.8 in/hr; substrata, less than 0.05 in/hr. Suitability: fair to poor. | Shearing strength: subsoil, low; substrata, very low. Compacted permeability: semipervious to impervious. Compressibility: very slight to medium. Stability: subsoil, low; substrata, low. Piping: high hazard. | Resistance to erosion, low. On tilled slopes over 8%. Establishment of vegetation, fairly easy. |

Table 16. Soil features affecting engineering practices for water impoundments or disposal, Puget Sound Area (con.)

| Soil Series and Type | Dikes or Levees | Farm Ponds | | Terraces, Diversions and Waterways |
|---|---|---|---|---|
| | | Reservoir Area | Embankments | |
| Winston gravelly sandy loam | Stability: low. Compacted permeability: semipervious. Shrink-swell potential: low. | Permeability: subsoil, 2.5-5.0 in/hr; substratum, 5.0-10.0 in/hr. Not suitable. | Shearing strength: low. Compacted permeability: semipervious. Compressibility: very slight. Stability: low. | Resistance to erosion, low. Establishment of vegetation, fairly difficult. |
| Woodinville silt loam | Stability: low. Compacted permeability: impervious. Cracks when dry. Shrink-swell potential: high. Piping hazard through: foundation - variable, low to high; fill - variable, low to high. | Permeability: subsoil, less than 0.05 in/hr; substratum, less than 0.05 in/hr. Not suitable. | Shearing strength: subsoil, very low; substratum, very low. Compacted permeability: impervious. Cracks when dry. Compressibility: low to medium. Stability: subsoil, low; substratum, low. Piping: variable, low to high. | Resistance to erosion, moderate. Establishment of vegetation, fairly easy. |
| Woodlyn silt loam | Stability: low. Compacted permeability: semipervious to impervious. Shrink-swell potential: moderate to low. Piping hazard through: foundation - high; fill - high. Suitability: good to poor when compacted with sheepsfoot roller. | Permeability: subsoil, 0.05-0.2 in/hr; substratum, 0.8-2.5 in/hr. Suitability: fair to poor. | Shearing strength: subsoil, very low; substratum, low. Compacted permeability: semipervious to impervious. Compressibility: medium to very slight. Stability: subsoil, low; substratum, low. Piping: high hazard. | Resistance to erosion, low. Establishment of vegetation, fairly difficult. |

# GLOSSARY

**ABLATION** - The process by which ice and snow waste away as a result of melting and evaporation.

**ABLATION TILL** - Relatively loose outwash or till from ablation of glacial ice.

**AFTERBAY RESERVOIR** - A reservoir downstream from a main reservoir and used for re-regulation of peak flows.

**ALTERNATIVE COST** - The cost of the least costly single-purpose alternative means of providing the same benefits. The alternative may be a single-purpose project at the same site.

**ANADROMOUS** - Pertaining to fish that ascend rivers to spawn.

**ANNUAL FLOOD** - The highest stage or the greatest discharge in a water year.

**ANNUAL FLOOD PEAK SERIES** - A list of all the annual peak flood discharges known, arranged either in order of magnitude or chronologically.

**ANNUAL LOW-FLOW** - The lowest flow occurring each year, usually the lowest average flow for periods of several consecutive days. Instantaneous low flow, unlike instantaneous peak flow, is usually of little interest.

**ANTECEDENT PRECIPITATION** - Precipitation that occurred prior to the particular event, condition, or time under consideration. Usually, it applies to that prior precipitation which is still effective in modifying infiltration or runoff.

**ARTIFICIAL RECHARGE** - The addition of water to the ground water reservoir by activities of man, such as irrigation or induced infiltration from streams, wells, or spreading basins.

**ASPECT** - The compass direction toward which the land slope faces. The direction is measured downslope and normal to the contours of elevation.

**ASSOCIATED COSTS** - The costs of the goods and services, over and above those included in project costs needed to make the immediate products or services of the project available for use or sale.

**AVERAGE ANNUAL COST** - The equivalent of the project costs reduced to an equivalent uniform annual cost by compound interest methods, and includes interest and amortization on the investment, plus replacement, operation, and maintenance of the project during its economic life.

**AVERAGE ANNUAL DAMAGES** - The weighted average of all damages that would be expected to occur yearly under specified economic conditions and development. Such damages are computed on the basis of the expectancy in any one year of the amounts of damage that would result from events throughout the full range of potential magnitude.

**AVERAGE ANNUAL EQUIVALENT DAMAGES** - Average annual damages over a specified period of time taking into account future changes in economic conditions and development by use of compound interest methods.

**BASAL TILL** - Compacted or cemented till resulting from glacial advance.

**BASE FLOW** - That portion of runoff not resulting from direct runoff of precipitation. It may come from ground water effluent, or delayed runoff from storage in lakes, swamps, glaciers, snow, etc.

**BASIN** - A geographic area drained by a single major stream.

**BED LOAD** - The sediment that moves by sliding, rolling, or bouncing on or very near the streambed; sediment moved mainly by tractive or gravitational forces, or both, but at velocities less than the surrounding flow.

**BENEFICIAL USE OF WATER** - The use of water for any purpose from which benefits are derived, such as for domestic, irrigation, or industrial supply, power development, or recreation.

**BENEFIT-COST RATIO** - The arithmetic proportion of estimated average annual benefits to average annual costs, insofar as the factors can be expressed in monetary terms; it is a measure of the degree of tangible economic justification of a project.

**BENEFITS** - Increase or gains, net of associated or induced costs, in the value of goods and services which result from conditions with the project, as compared with conditions without the project. Benefits include tangibles and intangibles and may be classed as primary or secondary.

**BIOCHEMICAL OXYGEN DEMAND (B.O.D.)** - The quantity of oxygen utilized in the biochemical oxidation of organic matter in a specified time and at a specified temperature.

**BRACKISH WATER** - Water containing dissolved minerals in excess of that passing drinking water standards, but less than that in sea water.

**CANOPY** - The cover or crown formed by the green leaves, needles, and branches of all trees.

**CARRYING CAPACITY (GRAZING)** - The total number of animal-unit months which are available from a given tract of land.

**cfs** - Abbreviation for cubic-feet per second.

**cfs-DAY** (Abbreviation for cubic-feet per second per day.) - The volume of water represented by a flow of 1 cubic-foot per second for 24 hours. It is equal to 1.983 acre-feet.

**CHANNEL STORAGE** - Water temporarily stored in a channel when inflow exceeds that which can be immediately discharged, resulting in an increase in water surface elevation. It is maximum when in a rising stage the inflow and outflow are equal and the depth of flow is a maximum.

**CLIMAX** - The final stage of a succession that continues to occupy an area as long as climate and soils remain unchanged.

**COMMERCIAL FOREST LAND** - Forest land which is producing or is capable of producing crops of industrial wood and not withdrawn from timber utilization by statute or administrative regulation. This includes both accessible and inaccessible areas and both operable and currently inoperable stands of trees.

**COMPREHENSIVE PLAN** - A plan for water resources development that considers all economic and social factors and provides the greatest overall benefits to the region as a whole

**CONDUIT** - A general term for an artificial or natural duct, either open or closed, for conveying water or other fluids.

**CONSERVATION STORAGE** - Water impounded for later release for consumptive uses, such as municipal, industrial, and irrigation.

**CONSTANT DOLLARS** - The real value of the dollar, with price of goods and services remaining constant; usually expressed over a period of time from a base year (equal to 100). The effect of using constant dollar is to remove changes in value of the dollar due to either inflation or deflation.

**CONSUMPTIVE USE (WATER)** - The use of water by discharge into the atmosphere or incorporation into the product of the process in connection with vegetative growth, food processing, or an industrial process.

**CONTAMINATION** - A general term signifying the introduction into water of micro-organisms, chemicals, wastes, or sewage, which may render the water unfit for its intended use.

**COST ALLOCATION** - The process of distributing project costs equitably among the various purposes served by the project.

**COST SHARING** - The contribution, by those benefiting from a project or program, towards the cost of the project of program.

**csm** (Abbreviation for cubic-feet per second per square mile.) - The average flow in cubic-feet per second from each square mile of drainage area. Its use allows direct comparison of runoff from basins of differing areas.

**CNU** (Abbreviation of Calculated Nutritional Unit.) - One-twelfth (1/12th) of the yearly requirement of digestible nutrients fed in a balance ration to a 1,000-pound beef cow, including the requirement to nurse and feed the calf to eight months of age at a weight of 475 pounds.

**DEBRIS** - Any material, including floating trash, suspended sediment, or bed load, moved by a moving stream.

**DEEP PERCOLATION** - In a geologic sense, the amount of water that is lost from a basin by leakage through the geologic formation.

**DESIGN FLOOD** - The selected flood against which protection is provided, or eventually will be provided, by means of flood protective or control works.

**DIRECT FLOOD DAMAGES** - Losses to existing and projected properties and improvements resulting from contact with flood waters.

**DRAINAGE WATER** - Water which has been collected by a drainage system. It may derive from surface water or from water passing through soil.

**ECOLOGICAL IMPACT** - The total effect of a change (either natural or manmade) in an environment upon the ecology of the area.

**ECONOMIC BASE STUDY** - A study which evaluates the economic structure of the region to provide economic projections necessary for the appraisal of future water resource needs.

**ECONOMIC JUSTIFICATION** - A condition existing when as a minimum, the estimated total economic benefits exceed the total economic costs and, in addition, each project purpose provides benefits at least equal to its separable cost.

**ECONOMIC LIFE** - That period of time, estimated by economic, technical, and social factors, after which the costs of continuing the project will exceed the benefits to be expected from continuation of the project.

**ENCROACHMENT (FLOOD PLAIN)** - Development and growth in the flood plain that constitutes an impairment to the flood flows or creates a flood-damage potential. Encroachment includes, but is not limited to, buildings, streets, structures, and plant growth resulting from changes in land use patterns.

**ENHANCEMENT** - A condition resulting from the development of a project such that the value of a natural resource is greater than that which existed under pre-project conditions.

**EPHEMERAL STREAMS** - Streams that flow only in direct response to precipitation. Its channel is above the level of the water table.

**EROSION CONTROL** - The application of necessary measures to minimize soil erosion by artificial structures or vegetative manipulation.

**EUTROPHICATION** - The process of overfertilization of a body of water by nutrients which produce more organic matter that the self-purification processes can overcome.

**EVAPOTRANSPIRATION** - The process by which water is transpired by plants, added to plant tissue and evaporated from the plant and surrounding surfaces. Quantitatively, it is usually expressed in depth of water in a specified period of time.

**EXCLUSIVE FLOOD CONTROL CAPACITY** - That reservoir space which is used for the sole purpose of regulating flood inflows to reduce flood damage downstream.

**FLOOD** - An overflow on lands not normally covered by water and that are used or usable by man.

**FLOOD PREVENTION** - Flood prevention is any undertaking for the conveyance, control and disposal of surface water caused by abnormally high direct precipitation, stream overflow, floodwaters or floods aggravated by or due to wind or tidal effects.

**FLOOD PROOFING** - A combination of structural changes and adjustments to properties subject to flooding primarily for the reduction of flood damages.

**FLOODWATER** - Surface accumulations of water, usually of a damaging nature resulting from overflow, abnormally high precipitation, or the results of wind and tidal effects.

**FLOWAGE EASEMENT** - A permit to allow for passage or temporary storage of floodwaters without a transfer of land ownership.

**FORB** - Any herbacious plant which is neither a grass nor a sedge.

**FRAIL LANDS** - High runoff and sediment producing areas characterized by steep slops, highly erodible soils, and sparse vegetative cover. Any area in a severe state of erosion or any area having inherent capacities to erode if not fully protected.

**GROSS INCOME** - Benefits or services rendered by an article of wealth or by free persons.

**GROUND WATER** - Water that is in the zone of saturation.

**GROUND-WATER BASIN** - A ground-water reservoir together with all the land surface and the underlying aquifers that contribute water to the reservoir.

**GULLY EROSION** - Removal of soil by running water, with formation of channels that cannot be smoothed out completely by normal cultivation.

**HIGH LEVEL CROP YIELD** - Harvested acre yield attained by the top five percent of farmers using good management and related conservation practice. Production hazards taken into account.

**HYDROLOGIC CYCLE** - The circuit of water movement from the atmosphere to the earth and return to the atmosphere through various stages or processes as precipitation, interception, runoff, infiltration, percolation, storage, evaporation, and transpiration.

**HYDROLOGIC SOIL COVER COMPLEX** - A combination of a hydrologic soil group and a type of cover.

**HYDROLOGIC SOIL GROUP** - A group of soils having the same runoff potential under similar storm and cover conditions.

**INFILTRATION** - The process whereby water from the surface enters into and passes downward through soil or rock.

**INFILTRATION CAPACITY** - The steady rate at which a soil, when in a given condition, can absorb water.

**INFILTRATION RATE** - The rate at which water flows downward from the surface into the soil. Water enters the soil through pores, cracks, worm and decayed-root holes, and cavities introduced by tillage. In many places, infiltration is restricted by surface sealing or crusting.

**INSTALLATION COST** - All cost for installing the works of improvement. Term includes cash payments, donated services and goods, land treatment measures, technical assistance, engineering costs, and costs of land rights and water rights.

**INTAKE RATE** - The rate at which water flows from the surface into and through the soil. It is the expression of several factors, including infiltration and percolation.

**INTANGIBLE BENEFITS** - Those benefits which, although recognized as having real value in satisfying human needs or desires, are not fully measurable in monetary terms, or are incapabile of such expression in formal analysis.

**INTANGIBLE DAMAGES** - Those damages that cannot be evaluated in monetary terms, such as loss of life, suffering, etc.

**INTERCEPTING DRAIN** - A drain constructed to intercept surface or groundwater flowing toward the protected area, from higher ground, and to carry it away from the area.

**IRRIGATION REQUIREMENT** - The quantity of water, exclusive of precipitation, that is required for production of food, fiber, or forage.

**IRRIGATION RETURN FLOW** - Water which is not consumptively used and returns to a surface supply. Under conditions of water-rights litigation, the definition may be restricted to measurable water returning to the stream from which it was diverted. See RETURN FLOW.

**JOINT COSTS** - Costs of facilities that serve more than one project purpose.

**JOINT USE FACILITIES** - The features of a project used in common for more than one project purpose, such as the dam in a multiple-purpose reservoir.

**JUSTIFICATION** - The analysis of the costs and benefits of a project or program to determine whether or not the project or program should be consummated.

**LAND CAPABILITY CLASSIFICATION** - Interpretive grouping of land made primarily for agricultural purposes. In this classification, arable and non-arable soils are grouped according to their potentialities and limitations for sustained production of the commonly cultivated crops or permanent vegetation.

**LAND ENHANCEMENT BENEFITS** - Those benefits resulting from the improved use of land, made possible by a project.

**LAND RESOURCE AREAS** - Broad, geographic areas having similar soil, climatic, geologic, vegetative, and topographic features.

**LAND SUBSIDENCE** - The lowering of the natural land surface in responce to: Earth movements; lowering of fluid pressure; removal of underlying supporting material by mining or solution of solids, either artificially or from natural causes; compaction due to wetting (hydrocompaction); oxydation of organic matter in soils; or added load on the land surface.

**LAND TREATMENT MEASURE** - A tillage practice, a pattern of tillage or land use, or any land improvement, with a substantial effect of reducing runoff and sediment production or of improving use of drainage and irrigation facilities.

**LEACHING** - The removal of soluble constituents from soils or other material by percolating liquid.

**LEFT BANK** - The left bank of a stream when the observer is facing downstream.

**MACROCLIMATE** - The general large-scale climate of a large area or country as distinguished from mesoclimate and microclimate.

**MAXIMIZATION OF NET BENEFITS** - Net benefits are maximized when the scope of development is extended to the point where the benefits added by the last increment of scale ( i.e., an increment of size of a unit, an individual purpose in a multiple purpose plan, or a unit in a comprehensive plan) are equal to the cost of adding that increment of scale.

**MEAN ANNUAL RUNOFF** - The average value of all annual runoff amounts usually estimated from the period of record or during a specified base period from a specified area.

**MEDIAN** - A value in a statistical (ordered) array having as many cases larger in value as cases smaller in value.

**MESOCLIMATE** - The climate of small areas of the earth's surface which may not be representative of the general climate of the region. It is intermediate in scale between macroclimate and microclimate. Places considered in mesoclimatology include small valleys, "frost hollows," forest clearings, and open spaces in towns.

**MICROCLIMATE** - The local climatic conditions, brought about by the modification of general climatic conditions by local differences in elevation and exposure. The detailed area of a very small area of the earth's surface.

**MITIGATION** - Providing of services or facilities to compensate for project detriments.

**MULTIPLE-PURPOSE PROJECT** - A project designed to serve more than one purpose; for example, irrigation, flood control, recreation, and hydroelectric power.

**MUNICIPAL AND INDUSTRIAL (M&I) WATER** - Water supplied to a central municipal distribution system and used in industry and commerce.

**NATURAL RUNOFF** - Runoff resulting from natural flow; that is flow unmodified by man.

**NEGATIVE BENEFITS** - Conditions, brought about by a program or the construction or operation of a project, for which corrections require the expenditure of cost or effort which would not have been required had the project not been constructed.

**NET INCOME** - The difference between income and costs of any article of wealth.

**NONRECURRING FLOOD DAMAGES** - Those items of previous loss which, although once experienced, are not likely to recur for various reasons, such as destruction and nonreplacement of the facility involved, or replacement in such a manner as to avoid or minimize further damage.

**NONREIMBURSABLE COSTS** - Costs for which the financing agency does not seek repayment through project revenues.

**NORMALIZED CURRENT PRICES** - Observed prices for the last year of record derived from computations or graphic readings of mathematically fitted (nonlinear) long-term trend lines.

**OPERATION, MAINTENANCE AND REPLACEMENT COSTS** - Average annual costs of project operation and normal maintenance and replacement, if necessary, at end of economic life.

**OPTIMUM DEVELOPMENT** - The optimum development of an area or a resource is that combination of scope and type of development which, when measured by economic, social, and other factors yields the most acceptable results.

**ORAGRAPHIC PRECIPITATION** - Precipitation which results from the lifting of moist air over a topographic barrier such as a mountain range. It may occur some distance upwind and a short distance downwind as well as on the barrier feature.

**OUTDOOR RECREATION** - Recreation in which the dominant environmental attraction is the out-of-doors.

**PARAMETER** - 1. A limiting factor of a particular situation, that defines other variables in the same situation.

2. A characteristic of a substance or situation that is used as a standard of comparison.

**PERMEABILITY** - The property of a material which permits appreciable movement of water through it when saturated and actuated by hydrostatic pressure of the magnitude normally encountered in a natural subsurface water.

**pH (HYDROGEN ION CONCENTRATION)** - Measure of acidity or alkalinity of water. Distilled water, which is neutral, has a pH value of 7; values above 7 indicate the presence of alkalies, while those below 7 indicate acids.

**PHREATOPHYTES** - Plants that habitually obtain their water supply from the zone of saturation, either directly or through the capillary fringe.

**POLLUTION** - The addition of sewage, industrial wastes, or other harmful or objectionable material to water.

**PRIMARY BENEFITS** - The value of goods and services directly resulting from the project, less associated costs incurred in realization of the benefits and any induced costs not included in project costs. Types of primary benefits may include domestic, municipal, and industrial water supply, irrigation, flood prevention, land stabilization, drainage, recreation, and fish and wildlife.

**RANGE MANAGEMENT** - The art and science of planning and directing range use to obtain sustained maximum animal production, consistent with perpetuation of the natural resources.

**REACH** - A specified length of stream, channel, or canal.

**RECHARGE BASIN** - A basin intended to increase infiltration for the purpose of replenishing ground water supply.

**RECONNAISSANCE ESTIMATE** - An estimate made in order to decide which features of a proposed project should be investigated in more detail.

**RECONNAISSANCE REPORT** - A report based on existing data and a minimum of reconnaissance field surveys which presents information on the potentialities of land and water resources in a given area to indicate whether further detailed investigations are justified.

**RECREATION DAY** - A statistical unit of recreation use consisting of a visit by one person for all or a portion of one day.

**REREGULATING RESERVOIR** - See AFTERBAY RESERVOIR.

**RESERVATION (PUBLIC LANDS)** - A withdrawal, usually of a more or less permanent nature; also, any Federal lands which have been dedicated to a specified public purpose.

**RETURN FLOW** - That part of a diverted flow that is not consumptively used and that returns to a surface supply.

**RIGHT BANK** - The right bank of a stream when the observer is facing downstream.

**RIPARIAN LAND** - Land which abuts upon the banks of a stream or other natural body of water.

**RIPARIAN VEGETATION** - Vegetation growing on the banks of a stream or other body of surface water.

**RIVER BASIN DEVELOPMENT** - A program to develop the use of the water and land resources of a river basin, so coordinated as to obtain a greater efficiency of use than would be possible if the resources were developed by uncoordinated multiple-purpose projects or a series of uncoordinated single-purpose projects.

**RUNOFF** - That part of the available water supply that is transmitted through natural surface channels.

**SALT-WATER INTRUSION** - The phenomenon occurring when a body of salt water invades a body of fresh water. It can occur either in surface or ground water bodies.

**SEASON** - A period of time characterized by some distinguishable occurrence of feature, such as growing season, harvest season, winter season, etc.

**SECONDARY BENEFITS** - The increase in the value of goods and services which indirectly result from the project under conditions expected with the project as compared to those without the project.

**SEDIMENT CONTROL** - The control of movement of sediment in a stream or reservoir by means of debris dams, wing dams, channelization, etc.

**SEDIMENT LOAD** - The total sediment, including bed load, being moved by a stream at a specified cross section.

SEDIMENT STORAGE - The accumulation, in a reservoir, of sediment that would be carried downstream in the absence of a reservoir.

SEEPAGE - The gradual movement or oozing of a fluid into or out of a porous medium.

SEPARABLE COSTS - Costs which could be omitted from total project cost if one purpose of the project should be deleted.

SHEARING STRENGTH - Shearing strength represents the combined effects of internal friction or the resistance of soil grains to sliding; and cohesion refers to the stickiness between particles. The shearing strength of each soil is evaluated as low, moderate, or high. A high shearing strength evaluation indicates little or no hazard of lateral soil movement. A moderate shearing strength evaluation indicates a moderate hazard of lateral soil movement. A low shearing strength evaluation indicates a severe hazard of lateral soil movement, and introduces severe constraints in the design of foundation footings for bearing strength.

SHRINK-SWELL POTENTIAL - Shrink-swell behavior is that quality of the soil which determines its volume change with a change in moisture content. Building foundations, roads, and other structures may be severely damaged by shrinking and swelling of soils. The volume change is influenced by the amount of moisture change and the amount and kind of clay in the soil. A low shrink-swell evaluation indicates little or no problem; a moderate shrink-swell evaluation indicates water control measures may be required, and that some foundation reinforcements may be necessary to prevent foundation damage. A high shrink-swell potential indicates complex water control measures will be required and extensive foundation reinforcements will be necessary to prevent severe damage.

SINGLE-PURPOSE STUDY - A study made to determine what features would be necessary to supply any single function of those included in a multipurpose project. These studies are done primarily to facilitate cost allocation.

SOIL - A natural, three-dimensional body on the earth's surface that supports plants and that has properties resulting from the integrated effect of climate and living matter acting upon parent material, as conditioned by relief over periods of time.

SOIL ASSOCIATION - A group of soils, with or without common characteristics, geographically associated in an individual pattern.

SOIL CLASSIFICATION - The systematic arrangement of soils into groups or categories on the basis of their characteristics.

SOIL CONSISTENCE - The relative mutual attraction of the particles in the whole soil mass, or their resistance to separation or deformation. The consistence varies with moisture content, and the degree of stickiness and plasticity is measured when the soil is wet and the degree of hardness or firmness when the soil is dry or moist.

SOIL HORIZON - A layer of soil, approximately parallel to the surface, that has distinct characteristics produced by soilforming processes.

SOIL MAPPING UNIT - A portion of the landscape that has similar characteristics and qualities and whose limits are fixed by precise definitions. Within the cartographic limitations, and considering the purpose for which the map is made, the soil mapping unit is the unit about which the greatest number of precise statements and predictions can be made. The soil mapping units provide the most detailed soils information and are the basis for all interpretive groupings of soils. They furnish the information needed for developing capability units, forest site groupings, crop suitability groupings, range site groupings, engineering groupings, and other interpretive groupings. The most specific management practices and estimates of yields are related to the individual mapping unit.

SOIL PROFILE - Refers to a vertical cross section of soil layers which are designated as A, B, C, and R horizons. The A horizon refers to the topsoil layer having the same color, texture, and structure. The B horizon is the layer immediately below the A horizon, and, with rigidly specified limits, has the same color, texture, structure, and chemical properties. This B horizon, also known as subsoil, is defined as the zone of accumulation to which clay particles, lime, iron, or silica compound are carried by suspension in water from the overlying layers. The C horizon, also known as the substratum, lies immediately below the B horizon and has about the same color and texture throughout its depth. This horizon is sometimes referred to as parent soil material because it is relatively unaltered, physically, chemically, or biologically from its original condition at the time the soil development process began. The R horizon refers to underlying bedrock.

SOIL SERIES - Soils in a particular soil series are essentially uniform in differentiating properties and in arrangement of horizons or layers. Soil type refers to surface soil texture. The series designation refers to soils with very similar profile characteristics.

SOIL STRUCTURE - An arrangement of textural aggregates of the soil mass. When broken, the mass tends to break into definite shapes and forms which are described as granular, blocky, prismatic, platy, or massive. Each of these forms is indicative of soil permeability, soil stability, and root penetration.

SOIL TEXTURE - The relative proportions of sand, silt, and clay particles in a mass of soil. The basic USDA textural classes, in order of increasing proportion of fine particles, are shown as follows:

| General terms | | Basic soil textural class names |
|---|---|---|
| Sandy soils - | (Coarse textured (soils | (Sands (Loamy sands |
| | (Moderately coarse- (textured soils | (Sandy loam (Fine sandy loam |
| Loamy soils - | (Medium-textured (soils | (Very fine sandy loam (Loam (Silt loam (Silt |
| | (Moderately fine- (textured (soils | (Clay loam (Sandy clay loam (Silty clay loam |
| Clayey soils- | (Fine-textured (soils | (Sandy clay (Silty clay (Clay |

Larger particles (gravel and cobbles) are recognized by modifiers of textural class names.

The American Association of State Highway Officials (AASHO) classify soil materials in seven principal groups. The groups range from A-1, which consists of gravelly soils that have high-bearing capacity and are the best soils for subgrades, to A-7, which consists of clay soils that have low strength when wet and are the poorest for subgrades.

The Unified Soil Classification System (Unified) identifies soils according to their textural and plasticity qualities, and groups them with respect to their performances as engineering construction materials. In this system soil materials are identified as coarse grained (8 classes), fine grained (6 classes), and highly organic.

The USDA textural classification chart and the accompanying charts showing the generalized relationships of the AASHO and Unified soil groups to the USDA textural classes are shown on the following page.

SOIL TILTH - The condition of the soil in relation to the growth of plants, especially soil structure. Good tilth refers to the friable state and is associated with high noncapillary porosity and stable, granular structure. A soil in poor tilth is nonfriable, hard, nonaggregated, and difficult to till.

SPECIFIC COSTS - Costs of facilities that exclusively serve only one project purpose.

STAGE - The vertical distance of the water surface in a lake, stream, or estuary above or below a fixed reference point.

STREAM REGIMEN - The condition of a stream and its channel as regards their stability. A stream or conduit is "in regimen" or "in physiographic balance" if its channel has reached a stable form as the result of its flow characteristics.

STAND, MEDIUM STOCKED - A stand 40-69 percent stocked with present or potential growing stock trees.

STAND, SAWTIMBER - Stand at least 10 percent stocked with growing stock trees, half or more of which are sawtimber or pole timber with sawtimber at least equal to pole timber stocking.

TANGIBLE BENEFITS - Those benefits that can be expressed in monetary terms based on or derived from actual or simulated market prices for the products or services, or, in the absence of such measures of benefits, the cost of the alternative means that would most likely be utilized to provide equivalent products or services.

**TRAFFICABILITY** - The load-bearing capacity under natural soil conditions.

**TYPE** - Classification based on predominate species of tree cover.

**WASH LOAD** - The finer part of the sediment load of streams; the part that can be transported easily in large quantities but is limited by its availability. It is that part of the sediment smaller than that found in appreciable quantity by sampling shifting portions of the streambed.

**WASTE-WATER RECLAMATION** - The process of restoring water from municipal, industrial, and agricultural waste for beneficial purposes, whether by means of special facilities or through natural processes.

**WATER-HOLDING CAPACITY** - The supply of moisture held by a soil after the removal of gravitational water.

**WATER REQUIREMENT (AGRICULTURAL)** - The total quantity of water, regardless of its source, required by crops for their normal growth under field conditions. It may include water applied in irrigation, precipitation, and ground water available to crops.

**WATER RIGHT** - A legally protected right, granted by law, to take possession of water occurring in a water supply and to divert the water and put it to beneficial use.

**WATERSHED MANAGEMENT** - The analysis, protection, development, operation, and maintenance of a drainage basin for the optimum control and conservation of all its resources including the quality, quantity, and timing of water produced by the basin.

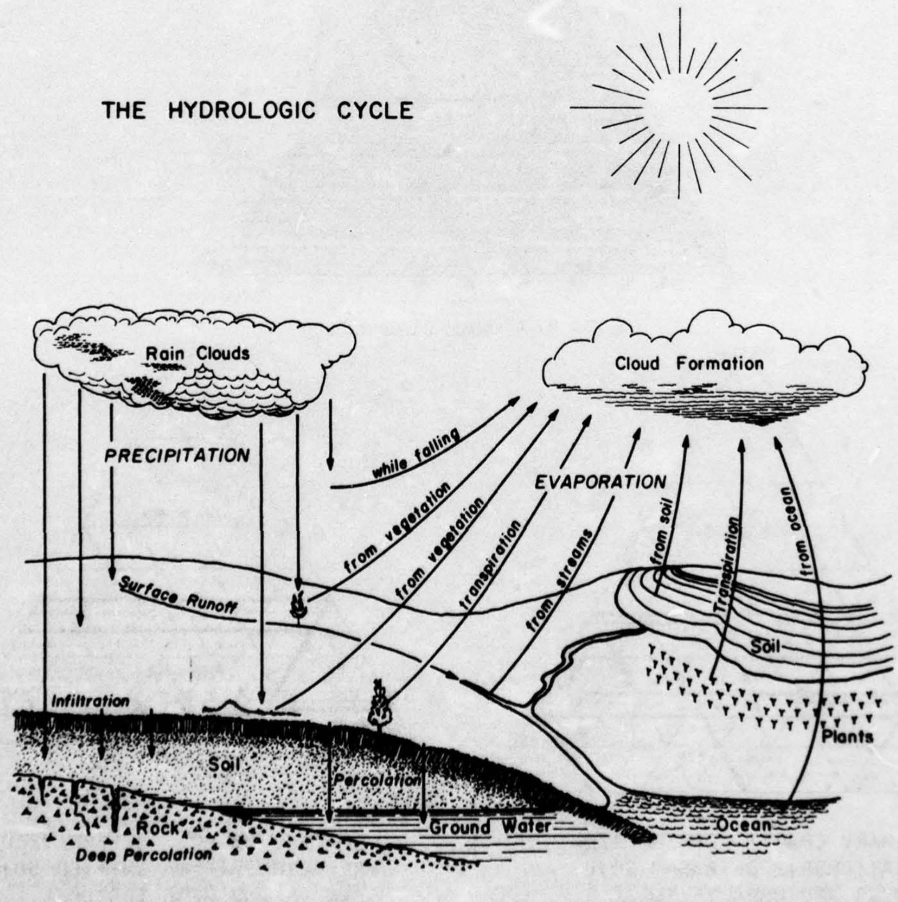
**WATER TABLE** - The upper surface of a zone of saturation, except where that surface is formed by an impermeable body.

**WETLANDS** - Lands covered by shallow water, marshes, and seasonally flooded lands subject to change through drainage or other land development measures.

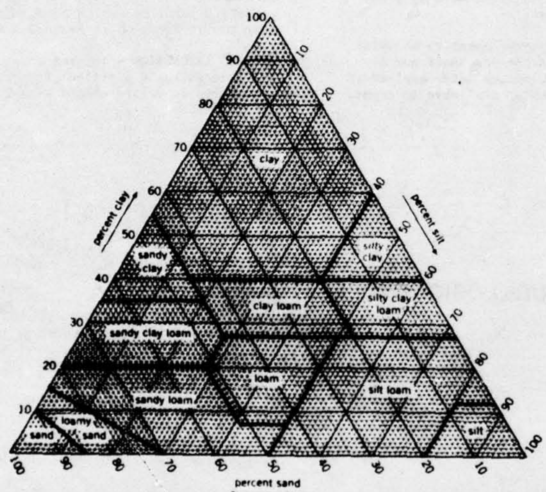
**WITHDRAWAL (PUBLIC LANDS)** - An action which restricts the disposal of public lands and which holds them for specific public purposes; also public lands which have been dedicated to public purposes.

**ZONE OF SATURATION** - The space below the water table in which all the interstices are filled with water. Water in the zone of saturation is called ground water.

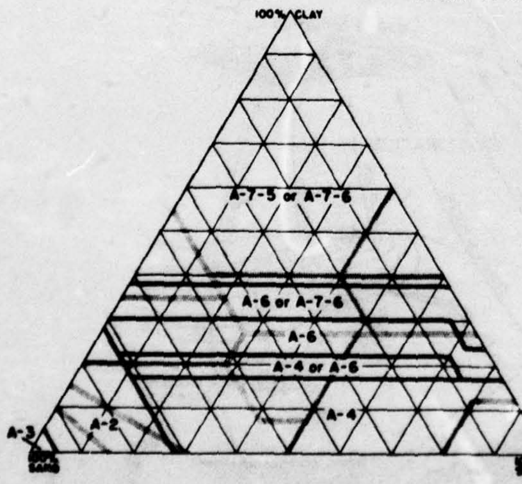
## THE HYDROLOGIC CYCLE



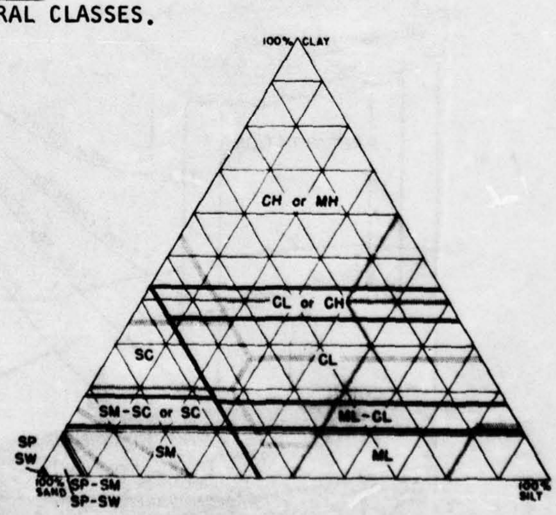
GUIDE FOR TEXTURAL CLASSIFICATION




USDA TEXTURAL CLASSES.




SUMMARY CHART: GENERALIZED RELATIONSHIP OF AASHO SOIL GROUPS AND USDA TEXTURAL CLASSES.




SUMMARY CHART: GENERALIZED RELATIONSHIP OF UNIFIED SOIL GROUPS AND USDA TEXTURAL CLASSES.

FILM

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